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STEPHEN H. GODDARD
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CHARLES T. CHILD
TECHNICAL EDITOR
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TO ADVERTISERS
CHANGES for advertisements should be in this office by Friday noon for the following week's issue.
NEW ADVERTISEMENTS should be in the office not later than Monday noon to ensure publication in that week's issue.

In the latitude of New York the first hot weather put in its appearance last week. One of the immediate though unexpected results was that in several of the larger office buildings in the business centre, part of the elevator service had to be discontinued on account of the setting to work of innumerable electric fans, absorbing a considerable part of the current generating capacity of the installed plants. In one great building, which has ten elevators, two were put out of service shortly after business hours for the day began, solely by reason of the starting of fans in the various offices. This fact gives about as telling an illustration of the importance of the electric fan as a current consumer as can be found.

AN INTERESTING PHYSICAL DISCOVERY.

Elsewhere in this issue there is printed a short communication from Professor John Trowbridge, of Harvard University, relative to an observation made by him upon the spectrum of an exceedingly powerful electrical discharge through the ordinary vacuum tube used in the study of the spectra of gases. Under the conditions of the experiments the discharges arose to values of ten thousand amperes for about one-millionth of a second. Under these circumstances the ordinary Plucker tubes used were destroyed after a few discharges, and immediately became coated inside with a white deposit of sodium salts coming from the glass. The interesting and important part of the observation, however, is that the spectrum exhibits dark lines as well as the normal bright lines, this showing an evidence of selective reversibility which may have far-reaching importance in the study of astronomical photographs. Exactly what they mean is hard to foresee or explain, but they parallel certain observations which have often been made upon the spectra of stars and nebulæ.

In certain recent observations, made upon the new star in the constellation Auriga, the evidence appeared to point more or less conclusively to the fact that, whatever was the nature of the inward disturbance which caused the apparent outburst of a new and brilliant star, succeeding manifestations might be explained by the outrush of electrical waves of prodigious energy from the centre of disturbance through a region of space filled with matter in the same condition as that found in the ordinary vacuum tube. In the initial stages of these appearances, where it might be assumed that the electrical stresses were of great intensity, some of the same phenomena of reversal of spectrum lines were noticeable. Indeed, they were so noticeable and so prominent as to lead to a variety of explanations of the observed phenomena, none of which seemed entirely credible. The results of Professor Trowbridge's work will be of no small importance in improving hypotheses of astronomical physicists while every such observation, by bringing out new facts, adds to the total of knowledge one more fact which either must find its place in accepted hypotheses, or else serve as the starting point for new and better ones.

THE SEASON OF MEETINGS.

The month of May, which is just ending, and that of June, which is just beginning, are unusually interesting seasons to the electrical fraternity because of the number of meetings of various societies and associations that are held in different parts of the country during the continuance of the pleasant spring and early summer weather. Already the National Electric Light Association, the Engine Builders' Association, the American Society of Mechanical Engineers, the Municipal Electricians' Association, and a number of less important societies have held their annual meetings for the reading and discussion of papers, and what is none the less attractive, for the having of a good time. The American Institute of Electrical Engineers will meet at Great Barrington, Mass., on June 17, 18, 19 and 20, and the Independent Telephone Association will meet at Philadelphia June 24, 25 and 26. In addition there will be a number of other meetings of engineering and scientific societies and associations, all of which will be of great interest to those indentified with the various branches of scientific and engineering activity represented.

This has come to be a country of conventions and association meetings. It has been found out that these meetings furnish the occasion not only for the presentation of papers, but also for that social intercourse which enables fellow craftsmen the better to know and understand one another's work. All such meetings, therefore, are productive of many good results even if no other end is attained than the formation by members and attendants of new acquaintances of more or less potential value.

SOME RATIONAL IDEAS OF WIRELESS TELEGRAPHY.

On another page will be found the second and concluding installment of Mr. Rankin Kennedy's short paper upon electromagnetic oscillations, or in other words upon a basic theory of wireless telegraphy. Mr. Kennedy's rank as an engineer and physicist entitles his opinions to respect, and he is evidently one of those who is not afflicted with the fatal habit of believing all he is told. Consequently, he has been unable to swallow or digest the usual statement that the workings of wireless telegraphy depend upon Hertzian waves, since he has been unable to see why such waves should be able to bend around the curved surface of the earth through many degrees of arc. In seeking for a simple explanation and one that seemed more in accordance with the observed facts, Mr. Kennedy has somewhat elaborated the hypothesis advanced in these columns in our number of January 11, 1902. In effect his suggestion is very plain. The earth may be regarded to all intents and purposes as an electrically charged sphere whose charge is at zero potential. If a disturbance is set up in this charge—which we are led to believe resides upon the surface of the earth—through the connection of an insulated capacity and a spark-gap with the earth, surges of current are caused to flow; then, inevitably, ripples of electrostatic disturbance will radiate out from the disturbing point and these may be detected at great distances by means of appropriate apparatus sensitive to electric waves. It makes no manner of difference whether the sending and receiving circuits are parallel.

A somewhat curious corollary of this hypothesis is that at the antipodal point from the sending apparatus there ought to be a maximum of effect. If the earth were a smooth sphere having a uniformly disturbed charge, the ripples radiating away from the disturbing influence in widening concentric circles would come together again at the other end of the diameter of the sphere, where their mutual interference and addition would create a point of maximum effect. It would not be extremely difficult to test this assumption. If it is found true the explanation of wireless telegraphy is evidently at hand. It may be remarked here that the antipodal point to Mr. Marconi's powerful sending station in Cornwall is to be found in longitude 175 degrees east, and latitude fifty degrees, thirty minutes south. This point is in the South Pacific Ocean, very near Auckland Island which lies immediately to the south of New Zealand. There the British Government maintains an admiralty supply depot. It would be very interesting to know if messages which have faded out and become no longer sensible to the receiving instruments at twenty-three degrees away from the sending station would not be again easily received one hundred and eighty degrees away at the antipodes. All that would be needed to try the experiment would be to send a ship provided with a receiving apparatus to the point indicated, and wait for results.

ELECTRICAL PHENOMENA IN VOLCANIC ERUPTIONS.

Among the few details that have been published concerning the exact nature of the terrible catastrophes which desolated two of the Windward Islands recently, all accounts agree that the eruptions were accompanied by atmospheric electrical disturbances of the most profound character. The cloud of hot dust and gases that fell from Mont Pelée upon the town of St. Pierre, according to all accounts was fringed with an almost incessant discharge of lightning, while at St. Vincent many persons fleeing from the shower of volcanic emissions were killed by lightning strokes.

Nearly all volcanic eruptions in which steam plays a prominent part seem to have been accompanied by more or less violent displays of lightning. It is not reported that overflows of lava have given rise to any marked display of lightning, but the explosive variety of eruption is almost invariably accompanied by tremendous electrical disturbances. Volcanic eruptions may be roughly grouped into two classes—those in which molten materials are, through some excessive pressure, caused to well up and overflow the crater of the mountain, and those in which the pent-up energies of the subterranean fires release themselves suddenly through an explosion, such as was the case in the recent West Indian eruptions. Of the precise nature of the disturbances leading up to such an eruption naturally no very definite knowledge can be had, but enough has been observed to warrant the belief that in nearly all cases they are due to the infiltration of water into hot strata at such depths that the pressure upon the rocks is enormous. Here, very likely, the materials of the rocks themselves are held in solution in water, heated to such a degree and under such a pressure that it loses all characteristics of the liquid with which we are familiar. In shifting of strata the changes that may occur to release this pressure will allow vast masses of intensely superheated water to burst violently and explosively into vapor, often carrying with it the shredded and disintegrated rock to condense in the form of dust, or in large aggregations as the porous material known as pumice-stone. The fact of the violent electrical disturbances under such conditions is an added proof of the soundness of the present theory of the formation of lightning.

As soon as any condensation takes place in the mass of up-rushing vapors small drops of water are formed, these drops exhibiting an electrical charge which may be due to any one or a combination of a large variety of causes. In consolidating themselves together into larger drops or masses these particles, assuming roughly a spherical form, soon exhibit a tremendous increase in their electrical charge, due to the fact that when a number of them aggregate to form a larger spherical drop, the diameter of the latter increases only as the cube root of the total rate of aggregation. In other words, eight small drops, each having an approximately equal small charge, unite to form another drop of twice the diameter of its constituents and having, therefore, only twice the electrical capacity, but with four times the charge, and consequently four times the electrical potential. In this way as the vapors aggregate, the drops forming around any dust particles or similar solid objects that may be present, the mass of condensing vapor increases in electrical potential until enormous voltages are attained and the lightning flash leaps to earth.

In volcanic explosions it is fair to assume from the conditions obtaining that the initial charge—whether this be due to friction or to chemical action and heat combined—may be very high, so the intensity and extent of the lightning phenomena exhibited will not be wondered at. The lightning is only one of the forms in which the released potential energy of the imprisoned hot liquids and vapors manifests itself.

The Scientific Basis of Spark Telegraphy.

(*Concluded from page 658.*)

The second metre rod was arranged perpendicular to the first and in contact. Fig. 7 shows that the oscillation was now of the same frequency as that in the sender. In each limb was a quarter wave, the corner being a potential node. The potential loop at 100′ had always a slightly smaller value than that at 100.

A receiver with limbs one and two

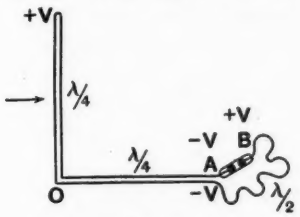


Fig. 9.

metres, respectively, was formed. The oscillations became more complicated. Fig. 8 gives the experimental curve obtained and hints that the oscillation is built up of a vibration whose wave-length equals the whole length of the receiver, and has potential loops at the middle and the ends, and one whose half wave-length is the length of the receiver with its node in the middle.

A wire loop, formed by folding once a wire two metres long, oscillated as if each half were independent. Fig. 6 represents the state of affairs in each limb. Severing the loop at the bend made no difference.

With each limb of the loop a prolongation one metre long was connected and stretched separately perpendicular to the respective limb of the loop. Each limb oscillated as a half wave-length of the fundamental emitted by the receiver, the two corners being potential nodes. Then a wire two metres long was connected to the end of one prolongation. The end of

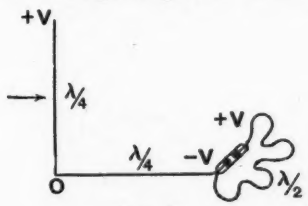


Fig. 10.

this extension wire gave a large micrometer reading. Other lengths than two metres gave smaller readings, which shows that in the extension wire an oscillation of wave-length four metres tended to establish itself. This arrangement is the disposition used in practical spark telegraphy (see *The Electrician*, p. 475, vol. xlvi), and is illustrated in Fig. 9. Since the potential at the ends, A, of both prolongations is the same, Count Arco gave the practical arrangement the simpler form of Fig. 10. These arrangements work without earth connection, and are, therefore, free from atmospheric disturbance. As the corner O is a node, that corner can, however, be earthed in practice.

To ascertain the law which connects the magnitude of the effect in the receiver with the distance between it and the sender, micrometer measurements were made on the receiver sketched in Fig. 11. The results are plotted in the figure, distances being abscissæ and the spark-lengths observed at the end of the prolongation wire being ordinates. The curve is hyperbolic, and indicates that within the limits of the experiments the effect on the secondary varies inversely as the first power of the distance.

OSCILLATIONS IN CLOSED CIRCUITS.

The theory of electrical discharge in

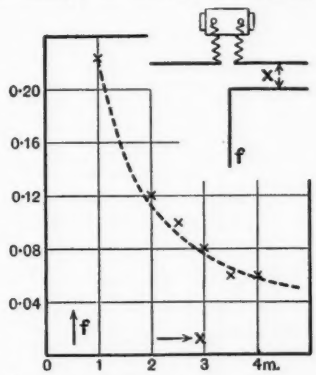


Fig. 11.

closed circuits possessing capacity and inductance was given by Lord Kelvin in 1853. His solution is based on the supposition that the current had the same value in all parts of the circuit at a particular moment. This supposition is equivalent to the assumption that the capacity of the conducting wire is negligible. It was desirable to determine whether this is near enough for practical purposes. The formula Lord Kelvin gave reduces to

$$T = 2\pi\sqrt{CL}$$

whence

$$\lambda = v\,T = 2\pi\sqrt{C\,v^2.\,L} = 2\pi\sqrt{CL}$$

where in the last expression C and L are both in centimetres. This formula was experimentally tested. A series of Leyden jars of known capacity was formed into a circuit, closed, but for a spark-gap, by a measured length of wire, different lengths being used in different experiments. The half wave-length of the oscillation was measured by finding the resonance length of an insulated wire acted on inductively. The measured wave-lengths were found to be considerably smaller than those calculated by Kelvin's formula. That this is likely may be seen by noticing that in the limiting case when the condenser has no capacity, the formula used above for straight wires gives

$$\frac{\lambda}{2} = 2\sqrt{CL}$$

where C is the capacity of the wire; while, if the capacity of the wire is negligible, we have Kelvin's formula, which yields results about thirty-six per cent larger than the other.

Kirchhoff has given the solution of the problem when the capacity of the wire is taken into account. Putting C′ for the capacity of the wire, and keeping C for the capacity of the condenser, as in Kelvin's formula, Kirchhoff's formula becomes

$$\frac{\pi\,l}{\lambda}\tan\left(\frac{\pi\,l}{\lambda}\right) = \frac{C'}{4\,C}$$

where l is the length of wire.

This equation reduces to the straight wire formula if C be infinitesimal, and to Kelvin's formula if C′ be negligible. To test this formula fresh experiments were made. An emitter of the Hertz form, consisting of two spheres at the extremities of a long straight wire broken at its middle to form a spark-gap, was used. It was suspended by insulating threads, and each half connected to a pole of an induction coil. The wave-length of the oscillations produced in this system was measured by finding the resonance length of a parallel straight wire. Different spheres and different lengths of wire were used in the emitter and the results used to evaluate the capacity of the wire. The capacity of the spheres and the inductance of the wire were calculated from the ordinary formula. The results for the capacity of the wire tallied remarkably well with the same quantity calculated directly, and

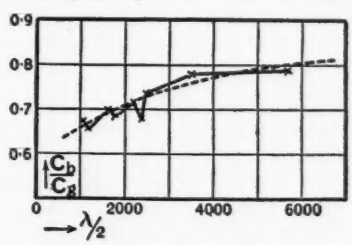


Fig. 12.

thus was demonstrated that Kirchhoff's formula can be absolutely relied upon.

Another set of experiments performed on an emitter, consisting of a circle of fine wire including large condensers and a spark-gap, led to the conclusion that Kelvin's formula may be used for the calculation of the wave-length when the quanti-

ties are of such relative magnitude that $\tan \frac{\pi l}{\lambda}$ and $\frac{\pi l}{\lambda}$ differ by not more than two per cent.

The measurement of the capacity of the glass jars used in some of these experiments led to difficulties. When measured by the ballistic method differences amounting to ten per cent were found in the value of the same jar according to the time it had rested discharged. This fact led to the institution of a series of experiments by which the capacity calculated from the measured wave-length and the known dimensions of the emitter could be compared with the value of the capacity as measured directly by the ballistic method. Experiments were made when the wave-length of the emitter was varied, with the results shown in Fig. 12. Here C_b is the capacity of a jar computed from the experiments, C_g its capacity measured directly. With the frequencies employed the value obtained by computation was, on the average, twenty-five per cent less than that obtained by measurement, and the figure shows that the effective capacity of a jar is dependent on the wave-length of the oscillations traversing it. This is, perhaps, due to the glass used as the dielectric.

The mode of sparking had no effect on the wave-length emitted by the sender. In most of the above experiments the spark passed in air across a gap of 1 cm. A spark of 1 mm. in petroleum gave, with the same apparatus, a wave-length measured to be exactly the same. The potential at the end of the resonating wire was much greater in this latter case, however, the spark in the micrometer being nearly ninety per cent greater.

In 1898 an assistant of Dr. Slaby's while sending messages noticed that a condenser placed in parallel with the spark-gap greatly strengthened the signals. This observation led to further experiments. A large Leyden jar placed in parallel with the spark-gap was found not to increase, but to diminish the effect, however. Quantitative experiments were, therefore, commenced. The arrangement in Fig. 13 was at length adopted, where the wire, DC, was at first thirty-nine metres (130 feet) long. From each of the ends, C and D, equal lengths were cut, and on each occasion a potential measurement made at these ends by the spark-micrometer. Fig. 14 gives the results, and shows that a wire length of thirty-five metres gave the highest potential measurement. Previous experiments had shown that 35.1 metres was the half wave-length emitted by the condenser circuit oscillating without wire wings. Thus the addition of wire wings made no difference to the proper period of the closed circuit. Moreover, for the greatest efficiency of the compound system it is necessary that the proper periods of the condenser circuit and the straight wire, respectively, should be the same. A potential node is formed at the mid-point of the straight wire, so it is essential that the wire be arranged symmetrically with the capacity circuit.

Chromite.

A discussion by Dr. Joseph Hyde Pratt in "Mineral Resources of the United States," 1901, published by the United States Geological Survey, gives some interesting information regarding this valuable material. The metal itself, chromium, is not used directly in the arts. The mineral chromite is used in the manu-

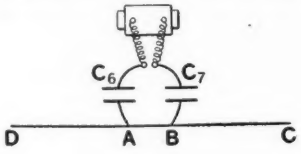


FIG. 13.

facture of brick for basic open-hearth furnaces. In one furnace over 400 heats have been turned out before the chromite brick lining had to be replaced. Chromite has been successfully tried as a hearth lining for water-jacket furnaces in copper smelting and its merits are said to be that it is infusible, that it does not become friable when heated and cooled, that it is not affected by sudden heating and cooling, and that it is not attacked by the products formed in the fusion of copper ore, and that, being very hard, it wears away very slowly under the flow of the fluids over it. There is no doubt but that this use will produce a demand for the chromite ores of North Carolina, which would be available for the smelters in the copper districts of Virginia and North Caro-

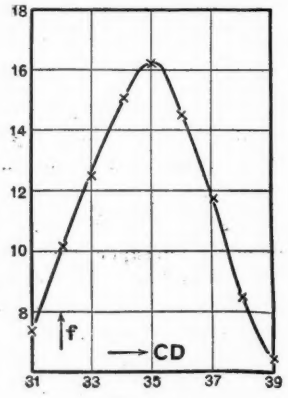


FIG. 14.

lina, the Ore Knob and Gold Hill copper districts of North Carolina and the Ducktown district of Tennessee. The chromite deposits of California should in the same way become valuable for the same purpose in the copper districts of Arizona, Utah and Montana.

The principal use of chromite as an alloy is as a ferro-alloy used with ferro-nickel very largely in making chromic steel for armor plate and armor-plate-piercing projectiles, for trolley car-wheels, crusher jaws, stamp-mill shoes, etc. Chromite in the presence of carbon makes steel intensely hard. The ferro-chromite alloy has to be produced under intense electric heat from high-grade ore low in silica.

Chromite has been found in quantity in Pennsylvania, Maryland, North Carolina and California. The North Carolina deposits are near Burnsville, Yancey County; near Dark Ridge Trestle, on Dark Ridge Creek, Jackson County, and sixteen miles northwest of Asheville, on Big Ivy Creek, Buncome County. The California deposits are found in Alameda, Calaveras, Del Norte, Fresno, Mendocino, Napa, Placer, San Luis Obispo, Santa Clara, Shasta, Sierra, Sonoma and Tehama counties. By far the greater part of the chromite used in the United States is brought directly from the deposits of Asiatic Turkey.

Since 1896 there had been scarcely any production of chromite in the United States until 1901, when California produced 368 long tons. The production of chrome ore in 1901 was 20,112 long tons as compared with 15,793 long tons in 1900.

ELECTROMAGNETIC OSCILLATIONS—II.

BY RANKIN KENNEDY.

(Concluded.)

In further elucidation of the manner in which oscillations are propagated over the surface of a large insulated globe from one point to another, according to the theory that it is the globe's electrical condition that is disturbed, and the oscillations are confined to a superficial charge, that fact that a globe even of the dimensions of the earth could be charged by a not unusual quantity of electricity is of importance, the amount is no greater than that required to charge an Atlantic submarine cable.

Now, supposing for a time we had a means of charging a globe, and the field of force produced polarized vertically, being a sphere, these lines would be radial all over the globe, and so long as no change occurred in the charge, no indications of its presence could be easily detected. And suppose again we had a means of detecting an electric field, akin to the magnetic needle, which detects a magnetic field and indicates its direction, this indicator would stand perpendicular to the surface. A detector of this kind for exploring electric fields can be best made of a dry pile. An extremely light dry pile delicately suspended when placed in an electric field at once aligns itself parallel to the lines of electric force, its positive end pointing to the negative pole and its negative end toward the positive pole, acting as a detector and indicator.

Placed in a field between neutral bodies it, like the magnetic needle, is indifferent or attracted in directions drawn by its own field; but suppose this electric needle suspended anywhere over the electrified globe, and the globe to be negatively electrified, the pile would be compelled to point its positive end downward, and if the globe's charge were reversed, the pile would be simultaneously reversed, making a half turn on its axis of suspension. And so by reversing the charge on the globe we could waggle the pile from side to side, no matter on what spot the pile happened to be situated on the globe, and these right and left swings could form ordinary needle instrument signals; therein we have the key to wireless telegraphy round a globe. This is represented diagrammatically in Fig. 2. At A is the supposed electric charge reverser, by means of which the globe can be charged positive or negative at will; at B we have the suspended pile, which will turn its one or other end downward according to the sign of the charge on the globe. So far then we could have wireless telegraphy all over a globe of any size, provided we could charge it electrically and reverse its charge at will. And it is quite practicable to work a model telegraph of this description, without wires over a large globe, with slow oscillations of charge over its surface. Applied to the earth as a globe we must, of course, explain where the opposite charge exists on the other side of the dielectric; that is the difficulty at first presented, but confining our consideration to the artificial globe at present, which being in a room or near the earth, there is no difficulty about the existence of the opposite charge. All that the experiment is intended to convey is that signaling between two points on a ball is perfectly feasible on ordinary electrostatic theories.

A Branly detector fixed to the globe would also respond to the reversals of charge, for a current would pass at each reversal. Thus, according to this theory, we confine our chief examination to the earth instead of neglecting the earth and going into the clouds.

The next hypothesis clears away the difficulty of the opposite charges required to work as in the foregoing experiment, for the opposite charges may be separated on the globe itself.

The oscillations may be set up on a ball without actual connection of the oscillator with the ball. This system has been employed on the Continent; the lower end of the oscillator terminates in a coil or plate which, although not directly connected to earth, is connected inductively thereto. Fig. 3 shows the application of the dry pile for the purpose of exploring electric fields stationary or oscillating slowly.

Clerk Maxwell assumed that electricity moved off from points at a high potential

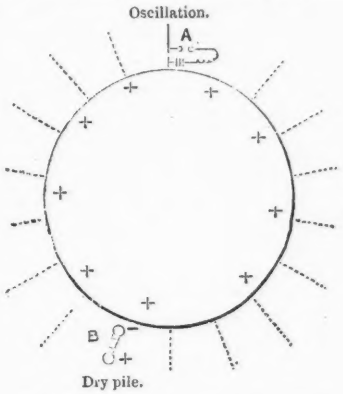


FIG. 2.—DETECTING OSCILLATIONS.

as a charged mass of air in the form of an invisible electric cloud, and showed by experiment that electrified air could exist in close proximity to the earth or conductors without discharge; and we must therefore not only consider the part played by the earth, but also that played by the atmosphere in any scientific explanation of wireless telegraphy other than that worked on the straight-line theory. To the man in the street it sounds convincing to tell him that the messages are conveyed by oscillations or "waves" in the

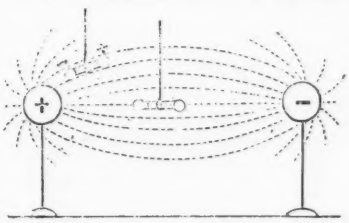


FIG. 3.—DRY PILE ELECTRIC FIELD EXPLORER.

ether traveling like light, but it is not convincing to the science student who wants to know how "they get round the corner."

Some experiments recently made by Mr. G. H. Barrus at the Manhattan Railway power station, London, showed that in a two-inch steam pipe 100 feet long, and under eighty pounds pressure, the condensation amounted to 60.3 pounds of steam per hour when the pipe was bare, and to 15.14 pounds per hour when covered. With steam at 100 pounds pressure the condensation, when uncovered, reached 72.20 pounds per hour. In a ten-inch pipe thirty-five feet long, carrying steam at 100 pounds pressure, the condensation, when uncovered, amounted to 112 pounds per hour, and when covered to but 15.93 pounds per hour. The temperature of the surrounding air ranged during the experiments from fifty degrees to seventy-five degrees Fahrenheit.

SOME EXPERIENCES WITH POWERFUL ELECTRIC DISCHARGES.

BY JOHN TROWBRIDGE.

In the employment of a battery of 20,000 cells to charge glass condensers I speedily discovered that glass plates less than one-eighth of an inch in thickness could not be used; for the sudden rush of a powerful charging current was sufficient to break down an insulation which would resist several hundred thousand volts accompanied by a weak charging current.

Moreover, it was not safe to build up the condensers made of glass plates, even of one-eighth of an inch in thickness in a compact form, like the leaves of a book; for the plates, under the tension of 20,000 volts, broke down, possibly from the effect of gliding discharges over the glass surfaces, from the edge of one coating to that of another; although the distance was made far greater than one would suspect should be traversed by such anomalous discharges. I am inclined to believe that the ozone produced in great quantity by the charging alters the surface conductivity of the glass and therefore enables a spark to leap from one condenser to another and thus to fracture the glass. It has become necessary to place the glass condensers I employ in racks, each condenser being separated by a space of at least two inches of air.

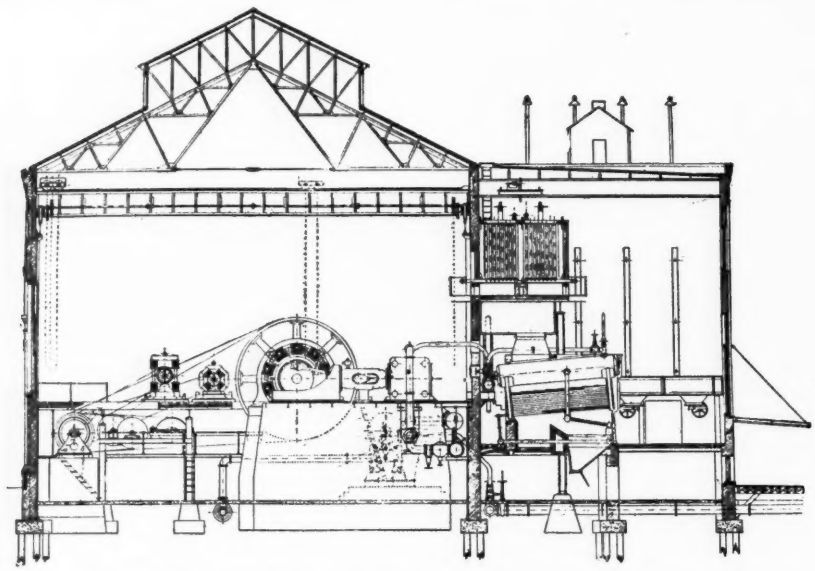
I find that the ordinary Plucker spectrum tube will stand a few discharges of a condenser of one half a microfarad charged to a potential of 20,000 volts. When the self-induction is reduced to the smallest possible amount this corresponds to a current of at least 10,000 amperes in about one millionth of a second. The spectrum tubes become coated immediately with a milk white deposit of sodium coming from the glass. The resulting spectrum contains dark as well as bright lines, and we thus have an evidence of selective reversibility of the silver salt which is of great importance in conclusions drawn from the study of astronomical photographs.

A tube filled presumably with dry hydrogen gives after a few powerful discharges when subjected to feebler alternating currents the spectra of argon. These arise probably from the dissociation of a trace of residual air in the process, of the dissociation also of water vapor, always present in glass tubes, together with the presence of an alkali like sodium.

The Toledo Railways and Light Company's Power Installation.

A Fine Combination Plant, Typical of the Best Recent Practice in the Middle Western States.

THE MARKED feature of the installation of the Toledo (Ohio) Railways and Light Company's system of electrical generation and distribution is the facility with which power can be concentrated upon any one of the considerable number of different kinds of loads, and the large number of uses to which power generated in a single station is applied through the district connected with it. In brief, there are three types of current supplied from this station; direct current at 110 volts on each side of a three-wire system; 550-volt direct current for street railway purposes; and a 2,300-volt distribution of alternating current on the three-phase system with the neutral grounded, permitting power to be taken off at 4,000 volts in each phase wherever it is necessary to bring the three phases together for power purposes.



CROSS-SECTION OF POWER STATION, LOOKING FROM SWITCHBOARD, TOLEDO RAILWAYS AND LIGHT COMPANY.

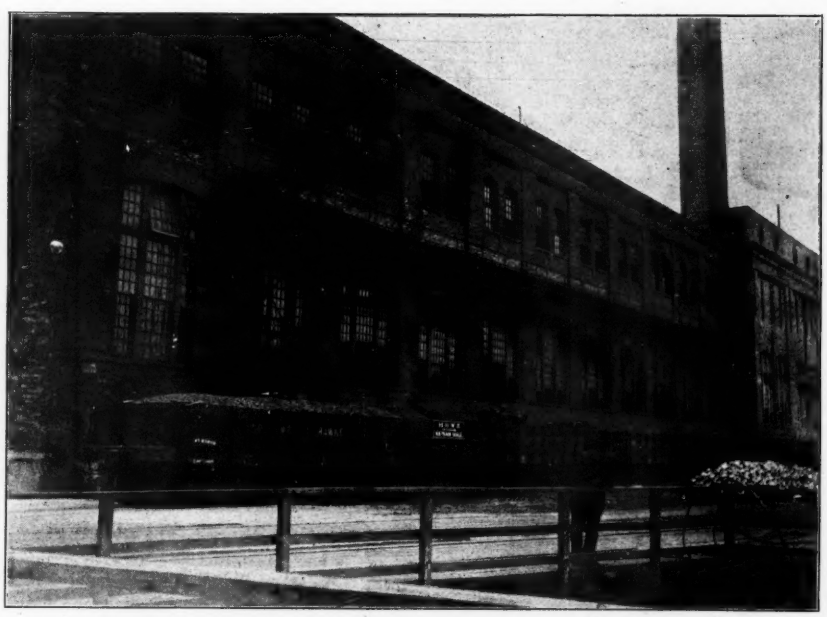
The buildings of the generating plant are located at the corner of Madison and Water streets, within 110 feet of the Maumee River. The building is of brick, fitted with a concrete flooring supported by brick arches, and a tile roof covered with slate over the engine room and tar and gravel over the boiler room. It is of steel frame construction of the usual type.

In ground area the building covers 34,320 square feet, and is divided into an engine room 312 by 70 feet, and a boiler room 262 by 40 feet. The structure is as nearly absolutely fireproof as a building can be made. Its foundation walls are of large ashlars of sandstone laid in cement concrete upon a concrete sub-foundation four feet deep. Deep piling was driven at three feet centres under the entire building.

Located in the boiler room are two batteries of Stirling and five batteries of Heine boilers, having a capacity of 5,496 horse-power, and carrying a steam pressure of 155 pounds per square inch. Nine of these boilers are equipped with the McKenzie traveling grate stokers, and stokers are on the ground for the completion of the other five.

On the boiler-room floor, on the south end, are located two Blake vertical feed pumps, 400 to 600 gallons capacity, one 6,000-horse-power Webster open feed-water heater, and above, between the breeching and south stack, is located one Green fuel economizer with 8,448 square feet of heating surface. In the north end of the boiler room, in the base of the stack, is now in course of erection the third Blake duplex boiler feed pump, with a capacity of 500 to 700 gallons.

The water for condensing, boiler feed and other purposes is taken from two intake wells under the dock by two sixteen-inch and one twenty-inch pipes. The discharge being carried back to the river by one thirty-inch overflow pipe, which will work in connection with a thirty-six-inch pipe now being installed.

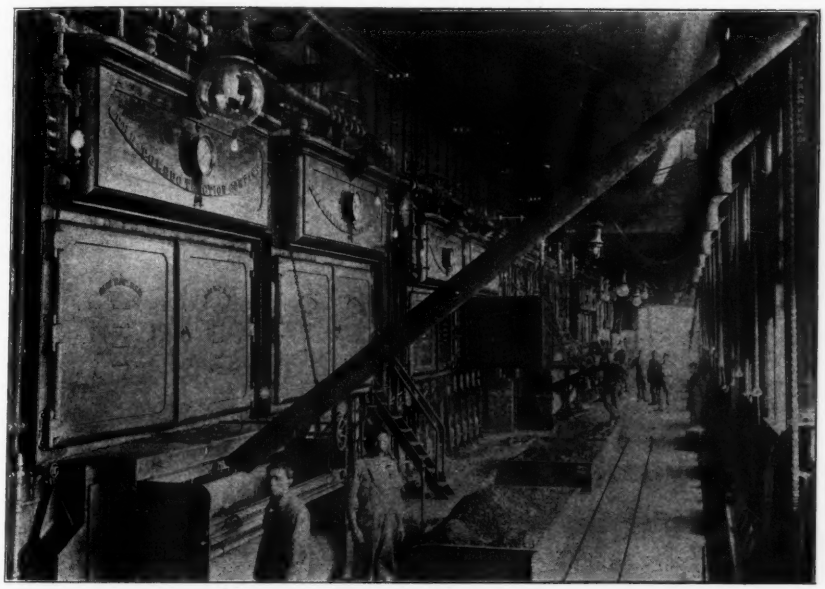


COAL AND ASH CONVEYOR, TOLEDO RAILWAYS AND LIGHT COMPANY.

On the east side of the boiler room is located a forty-ton McCaslin overlapping bucket coal conveyor, running the entire length of the boiler room. Parallel to the conveyor is a private switch from the Manufacturer's Railroad, elevated about

four feet above the bottom run of the conveyor, which allows coal to be handled from the cars to the conveyor by portable hoppers. The coal is conveyed to a 600-ton bin, located twenty-eight feet above the boiler-room floor at the north end.

The refuse materials from the boilers are also handled by this conveyor and elevated to a bin located in front of the north-end stack, from where they are loaded into railroad cars by gravity.



Boiler Room, Toledo Railways and Light Company

There are two steel stacks, one located at the north and the other at the south ends of the building. They are respectively 14 feet 6 inches in diameter by 215 feet high and 13 feet in diameter by 215 feet high, both lined inside with fire tile.

In the engine room there are at present four Wheelock, two Porter-Allen, two Allis and one Williams engines. There is in course of construction an additional Allis engine, 44 and 88 by 48 inches, vertical cross-compound, 3,000 horse-power nominal, 5,000 horse-power maximum and direct-connected to a 2,000-kilowatt, 575-volt, Westinghouse railway generator. The two Allis engines now in operation are vertical cross-compounds, worked condensing. One is a 28 and 60 by 48-inch, eighty revolutions per minute, and is direct-connected to a 1,050-kilowatt, 575-volt Westinghouse railway generator, and the other is a 28 and 60 by 48-inch engine, running at ninety revolutions per minute, and is direct-connected to three General Electric generators, each of 500 kilowatts, of which two are direct current, 150-volt, supplying current for the three-wire Edison system, and the other is an alternating three-phase generator with a voltage of 2,300 and 4,000 volts between the neutral of the star-connected armature and the three branches respectively. This machine supplies current for incandescent and arc alternating lamps.

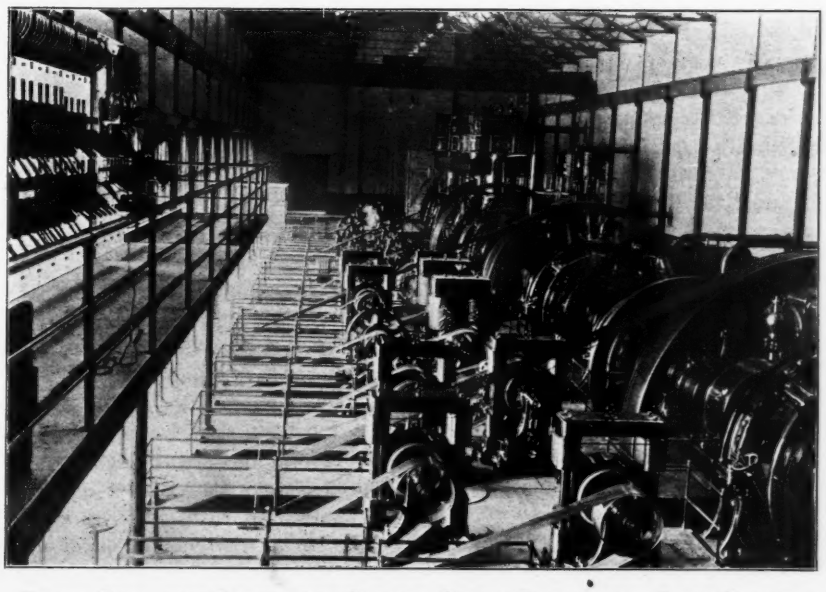
The No. 1 Wheelock engine is a horizontal cross-compound condensing machine, 18 and 48 by 48 inches, running at ninety revolutions per minute and direct-connected to a 500-kilowatt, 270-volt direct-current General Electric generator, supplying current on the outside bars of the three-wire Edison system. Nos. 2, 3 and 4 Wheelock engines are direct-connected to 500-kilowatt General Electric generators (railway) and are of the same dimensions as No. 1. They also have the Hoadley system of rope transmission, and are coupled to a line shaft with a quill and friction clutch. The line shaft is cut into four sections, with a friction clutch between each section, so that the four engines may be connected together or run independently. The two Porter-Allen engines are 16 and 36 by 30 inches in size, tandem-compound, condensing, with an independent Blake condenser, and are direct-connected to two 200 kilowatts each, 135-volt General Electric generators. The Williams engine, 19 and 38 by 32 inches, and working at 125 revolutions per minute, was formerly used on the single-phase alternating system, but as this system has been replaced by the three-phase system the engine is at present out of service.

There are seven 125-light, two 80-light, and four 60-light Wood arc machines; two 85-light Brush arc machines; two 150-kilowatt, 2,300 to 4,000-volt three-phase alternating General Electric generators; one 150-kilowatt and two 100-kilowatt General Electric boosters and two 100-kilowatt, 110-volt direct-current General Electric generators belted to a six and one-half-inch line shaft, 176 feet long, located underneath the engine-room floor. All the driving pulleys on this line shaft are equipped with Hill friction clutches, which are operated from the engine-room floor.

There has been recently installed a 400-kilowatt Westinghouse rotary converter, and appropriate transformers giving 240 volts direct current to 2,300 and 4,000 volts alternating current or *vice versa*.

The total generating capacity of the plant at present is 9,228 electric horse-power, and with the 2,000-kilowatt generator now in course of construction, the total capacity will be 11,908 electric horse-power.

In the engine room is also located a twenty-ton crane with seventy feet span, made by the Brown Hoisting Company.



Engine Room, from Switchboard Balcony, Toledo Railways and Light Company.

The switchboard is located at the south end of the engine room and is 135 feet in length, running 70 feet across the south end and 65 feet along the west side of the room; the width of the gallery is 13 feet and it is elevated 14 feet above the engine-room floor. The entire switchboard was built by the General Electric Company, and consists of 916.6 square feet of 2-inch white Italian marble.

THREE PHASE VS. TWO PHASE FOR CITY DISTRIBUTION.*

BY B. A. BEHREND.

The question whether or not the three-phase current is superior to the two-phase current for the distribution of light and power in cities, has been argued for the past eight years. At first, there were a great many advocates of the two-phase current, on account of the greater simplicity of this system. Looking to-day over the installations of alternating-current systems for city distribution, we find the fact established that the three-phase distribution has been preferred to the two-phase distribution in the majority of plants.

That system will be most favorable for distribution of light and power in which the potential on one phase is as little as possible affected by a change on load on another phase. This may be considered the criterion by which to form an opinion of the superiority of one system over another.

At first sight, it would seem that the two phases in a two-phase generator, being in quadrature with each other, would not be subjected to mutual induction. We must consider, however, that the two armatures of a two-phase machine—although displaced toward one another by ninety electrical degrees, and, so far as this displacement is concerned, being independent of one another—are electromagnetically connected with each other through the revolving field. We therefore find that the two phases in a two-phase machine are not independent of one another; that is, a load on one phase affects the potential on the other.

Theoretical considerations, as well as experience, have established the fact that a two-phase machine, so far as independence of phases is concerned, is not superior to a three-phase machine if the load on the latter is properly arranged.

The output of a two-phase generator is equal to the output of a three-phase generator. In other words, any two-phase generator may be wound as a three-phase generator without changing the rating, and *vice versa*.

The regulation of both two-phase and three-phase machines being equally good, according to the statements above made, it would seem that the three-phase system was preferable to the two-phase on account of requiring only three wires instead of four, leaving out of consideration the two-phase, three-wire system. There is, however, a very interesting fact which should be observed, namely, a three-phase generator on which the load is connected between the outside wires is greatly inferior to a two-phase so far as regulation is concerned. Only, if the neutral connection of the three-phase generator is made use of, and if the load is put on between the neutral and the outside wires, the regulation in the three-phase machine is, in all respects, equal to that of the two-phase machine. But it must be observed that the three-phase machine requires, under these conditions, four wires, as well as two-phase machine.

Summing up the pros and cons, we may state that there is comparatively little choice between the two-phase and the three-phase systems, but there are certain slight advantages in favor of the three-phase system. If seventy-five per cent of the load is a lighting load and twenty-five per cent is a load that requires little attention to regulation, as, for instance, an arc-light load having its own regulator, or a motor load, a three-phase generator has the further advantage that it can be operated as a single-phase machine, the lighting load being connected between two outside wires. In this case the lighting load can be very easily regulated, while no attention need be paid to arc light or motor load, as that is supposed to take care of itself.

* Read before the National Electric Light Association at its twenty-fifth convention, held at Cincinnati, Ohio, May 20, 21 and 22, 1902.

DOES IT PAY TO CREOSOTE WOODEN POLES FOR ELECTRIC LINE WORK?*

BY W. E. MOORE.

An electric lighting system may be divided into three principal parts, *viz.:* The generating station, the distributing lines and the house wiring, with lamps, motors, meters, etc.

At the various conventions of this association numerous papers have been read tending to show how the cost of production and reliability of service may be increased by various improvements in the generating plant. We have also had numerous papers on arc lamps, their light-distribution curves, power-factors and their different systems of operation; on incandescent lamps with their candle-hour and efficiency curves, and on meters which now determine almost entirely the revenue of the company. There has, however, been very little said on the distributing system and how to reduce the expense of maintaining the lines, notwithstanding that in the operating expense of most companies approximately one-third of the income goes toward the distributing expense, of which the maintenance of lines constitutes quite a large item. The principal cause of the depreciation in the lines is due to the decay of poles, for as yet but few lighting companies have begun the use of iron or creosoted poles, though iron poles are extensively used for street railway purposes.

The wooden pole is usually of cedar, sawed-heart pine, cypress, juniper or red wood, and is generally used on account of its low first cost and the comparative safety with which workmen may handle the live wires when standing on the cross-arms, as wood is a fair insulator.

Red-cedar and white-cedar poles, while they have a comparatively long life, have now become so scarce that it is extremely difficult to secure them in sufficient numbers of suitable sizes for electric light lines at any price in the eastern or southern market, though there is yet a considerable supply of white cedar to be found in the Northwest. Cedar, when of good quality, has the capacity of resisting the attacks of insects and fungous growths to a greater extent than any other wood used in this country for poles. This statement applies only to the heart of the stick, and more especially to red cedar; the sap or white portion quickly rots away at a point near the ground.

In the southern and eastern states cypress is largely used, and in its natural state has a life of from five to six years in the southern portion of the United States, and a somewhat longer life in the North.

Heart-sawed pine poles have a somewhat longer life than cypress, ranging from eight to nine years; but sap pine, though readily secured in sticks of suitable size and of the necessary length, is never used on account of its rapid decay. It lasts scarcely more than three years when used without being treated with some preservative compound. It is much more expensive to renew decayed poles than the original cost of setting them, due to the fact that they do not all decay at one time, and it is therefore necessary to set them piecemeal; and it is also necessary to take care of the wires while they are being reset, which is often quite expensive in case there are a large number of wires attached to one pole, especially junction poles.

For this reason the Augusta Railway and Electric Company began some nine years ago to study the problem of treating

* Read before the National Electric Light Association at its twenty-fifth convention, held at Cincinnati, Ohio, May 20, 21 and 22, 1902.

poles by some preservative compound to increase their life. Our first experiment consisted of charring the butts of the poles up to and about one foot above the earth line, and then saturating them with a coal-tar paint; but this was found to be of little service. We then tried painting the poles with various brands of preservative compounds sold under different trade names. These also were found to be of little or no benefit. In the meantime our poles, which were almost entirely of cypress, continued to rot out after an average life of about five or six years.

Some three years ago, after having investigated the results obtained both in this country and abroad from creosoting poles, we purchased and installed a creosoting plant capable of treating both poles and cross-ties. This plant consists of a steel cylinder 6 feet in diameter by 102 feet long, with heavy cast-iron heads, securely supported on hinges and arranged to be clamped against a fibrous gasket on the head of cylinder in a secure manner so as to resist a hydrostatic pressure of 150 pounds. This cylinder has a narrow-gauge railway laid through it with tracks continuing beyond the ends, of cylinder; there is sufficient ground room at one end for untreated poles, and at the other for treated poles. The cylinder has a series of inch pipes laid from end to end and covering the bottom side between its tracks. These pipes are arranged to be supplied with steam from an eighty-horse-power return tubular boiler, which is superheated, by means of pipe coils in a separate furnace, to a temperature of approximately 400 to 500 degrees. To the cylinder is also connected a fourteen-inch by twenty-four-inch direct-acting vacuum pump, and, again, a fourteen by ten by eighteen-inch direct-acting oil-pressure pump.

The poles are loaded on to a train of iron cars which are then drawn through the cylinder by means of a wire rope attached to a hoisting engine. The cylinder doors are bolted up tight, after which live steam is turned on the cylinder until a pressure of eighty pounds is reached, which is maintained while superheated steam is being circulated through the heating coils in the bottom of the cylinder. This steaming process is continued for a period of from four to six hours, depending upon the size of timber that is being treated. The steam pressure is then drawn down and a vacuum is pumped in the cylinder containing the timber, which has been heated up to a temperature approximately 350 degrees. The effect of evacuating, which lasts from six to four hours, is to season the green timber by drawing the sap and air from its pores. This is facilitated by the steaming to which the timber has been subjected, which has had the effect of dissolving the sap and raising it to a temperature far above the boiling point, due to reduced pressure when the vacuum is applied. The sap in the pores of the wood is immediately volatilized upon the application of vacuum, which has the effect of making the extraction of both sap and air very rapid and complete. After a treatment in the vacuum lasting from four to six hours, during which time a quantity of sap is pumped from the cylinder through the vacuum pump, the valve connecting the oil-storage tanks, which are of 30,000 gallons capacity and located in a pit below the cylinder, is opened and the atmospheric pressure forces the creosote oil up into the cylinder until it is filled. After this the oil-pressure pump is started, drawing its supply from a tank which has a gauge attached, calibrated to gallons. After the pump has completely filled the cylinder, its operation is continued until the required number of gallons of creosoting oil have been pumped into the cylinder to saturate the timber, the cubic contents of which have previously been figured, to a density of ten to twelve pounds per cubic foot. This ordinarily requires a pressure of sixty pounds of oil per square inch, applied for a period of time ranging from two to four hours, depending upon the diameter and kind of timber being treated. After the required number of pounds of oil have been injected into the timber the oil is drawn from the cylinder into the storage tanks and the steam is left circulating through the superheating coils for about one hour, which is done for the purpose of somewhat decreasing the oil drippings from the timber which would otherwise take place.

It must be understood that steam is circulated through superheating coils located in the bottom of the cylinder throughout the entire process which ranges from sixteen to twenty-four hours. The doors of the cylinder are then opened and the cars with their load of treated timber are drawn through the cylinder to the unloading yard by means of the hoisting engine applied through a wire cable. Another train of cars, which is standing already loaded at the other end of the cylinder, is immediately drawn in and the process repeated.

The approximate cost of the average size (say thirty-four feet, eight-inch top diameter) of cypress pole in the South ranges from $1.75 to $2.50 each, and the cost of creosoting approximates $20 per 1,000 feet board measure or about twice the first cost of pole. While we have no time test showing the ultimate life of creosoted poles in actual service, we have every reason to believe that their life will be prolonged four to six times that of untreated timber. The Bell Telephone Company has used creosoted pine poles for upward of ten years, and where the treating has been properly done they have yet to show the first signs of decay. Sir William Preece, of the British Telegraphic Department, reported that creosoted poles had been in use in England for more than thirty years without showing indications of decay. Since the cost of treating a pole averages about twice its first cost, the economy of creosoted poles must be apparent to all. The art of treating wood for its preservation is an old one, having been practised in one form or another for many years. Among the various chemicals used are chloride of zinc, zinc and tannin, sulphate of copper, bichloride of mercury, wood-creosote oil and dead oil of coal tar. The latter is the more generally used chemical for wood preservation, and it is also more expensive than any other. But the treatment of wood with creosote oil from coal tar has been far more successful and generally used than any other process.

Thus far we have found only one objection to creosoted poles, which is due to the tar acids contained in the creosote oil, principally carbolic acid. The effect of this acid is to make the handling of the poles disagreeable, as it inflames the hands of those who handle them, and at the same time it lowers the electrical resistivity of the timber to such an extent that linemen can no longer depend upon the poles to insulate them from the ground when handling 1,000 to 3,000-volt wires.

The principal preservative property of creosote oil appears to be due to naphthalene, which is deposited in the pores of the wood, together with the antiseptic acids always contained in dead oil of coal tar.

Large deposits of ozokerite are reported in the extreme north of Finland. The deposits are found in a bed of the Kemiokin River and are said to be extremely rich in paraffin.

What is known as the oil concentration process for sulphurets—with more exactness it should be oil separation process—is said to effectively separate chalcopyrite from magnetite. Magnetic concentrators will also make this separation.

WHAT EFFICIENCY LAMP SHOULD BE USED, AND HOW MAY THIS EFFICIENCY BE DETERMINED FOR ANY PARTICULAR STATION?—II.

A DISCUSSION BY HENRY L. DOHERTY, SAMUEL E. DOANE, L. G. VAN NESS AND FRANCIS W. WILLCOX.

L. G. VAN NESS (*Continued*).

We have thus far neglected to mention one important item. In the tables showing period of renewals we find that 3.1-watt lamps must be renewed every sixty or seventy days to prevent midnight consumers from burning their lamps beyond their useful lives. Some of these lamps will burn all night and reach their limit in thirty days. Now just what the period of renewal should be is a matter of conjecture with many of us, but it would scarcely be practicable to renew every thirty days; neither can we neglect these long-hour consumers, as we should be depriving our very best consumers of the benefits that the system was devised to give. It may be noted that the consumption per lamp per hour will guide us in the solution of this question for an average consumer. If, however, we have a great many short-hour consumers, say in the residence section, and a few long-hour consumers, it might be profitable to give them lamps of different efficiencies, though such practice often leads to serious trouble. With so many questions to deal with, it is difficult to state just how to go about it to determine what efficiency lamp should be used in any particular station.

The cost of lamps and of renewing them may be easily determined for any particular station. This may be reduced to a kilowatt-hour basis by estimating the life of the lamp on the regulation obtained in that station. To the above we must add the increased fixed cost to provide capacity for low-efficiency lamps, which is reduced to a kilowatt-hour basis by the average consumption per lamp per year in that station. Then by determining the costs proportional to output in that station we can calculate the increased cost for extra current for low-efficiency lamps. Comparing the sum of these quantities for the several lamps, we can see the effect of using the different efficiencies if we ignore the effect on the consumers. It would probably not be good practice to change the efficiency of lamps if the costs appear about the same for two efficiencies, though a gradual change of efficiency might be started; that is, we might burn a low-efficiency lamp at a little higher voltage, or burn a high-efficiency lamp at a lower voltage than rated. This could be continued until we arrived at the proper efficiency as selected. It might be good policy for us to use a low-efficiency lamp and make a reduction in rates. While we may not actually reduce rates, we may derive some benefit from the fact that the rate per kilowatt-hour has been reduced.

We hear much about the higher temperature of the high-efficiency filament which is supposed to give us a light of better quality, but I think the average is not wholly with the high-efficiency lamp. On nearly all of our stations a 3.1-watt lamp becomes a 3.5-watt, or lower, in 400 hours. Is it better to start with 3.1 and go to 3.5 watts in 400 hours, or to start with 3.5 watts and go to a four-watt lamp in 750 hours? The 3.1-watt lamp deteriorates more rapidly, taking but 400 hours to reach the initial temperature of the 3.5-watt lamp. If it is not removed promptly it will go to the final temperature of the 3.5-watt lamp in about 500 hours, and will probably break at about 550 hours. The 3.5-watt lamp deteriorates slowly, and if it is allowed to remain on the circuit beyond its useful life it is not so apt to cause complaint, for the reason that the decline is slow and not so likely to attract attention.

To sum up, I might say that I think the best way to answer the questions propounded is to face the situation squarely and figure it out for ourselves. If we allow the lamp salesman to do our calculating, we shall in all probability use 3.1-watt lamps. I do not say this to cast reflections on the lamp salesmen, as I think they have been only too active and energetic in advancing their side of the question. I think if more of us did our own calculating we should be using more low-efficiency lamps and giving a more uniform and satisfactory service. There are stations in which 3.1-watt lamps can be used to advantage, but I think the use of 3.1-watt lamps has been forced far beyond the point that would be determined by true economy and satisfactory service.

BY FRANCIS W. WILLCOX.

The importance of determining the best lamp efficiency can hardly be overestimated, for the selling side of the lighting business is one wherein much money can be lost or gained. It is all well enough to give the expense side full attention; the savings, however, that are effected in station operation through the expenditure of goodly sums for reconstruction can be quite readily offset by the effect of improper lamps. Through the supply of lamps of too low efficiency, or through general neglect of lamps—by failing to supply free or low-priced renewals and thereby permitting all kinds of lamps to go into service—managers are led into price reductions, to the giving of allowances, to indiscriminate rate-making and kindred evils that seriously reduce profits. Furthermore, the introduction of the electric light into stores and residences is by the same causes retarded and long hours of use by consumers (the most profitable character of service) is discouraged. This question, therefore, comes home to every central station, and there should not be one that admits, either by word or by the act of failing to control and regulate the lamps in use on its circuits, that it is indifferent to the question of the best lamp efficiency.

DEFINITION OF THE TERM "BEST EFFICIENCY."

It is necessary, first of all, to define the meaning of the expression "best lamp efficiency." It does not necessarily mean the highest efficiency, nor the efficiency that gives the longest lamp life. The term "best" as used here means, as I take it, the most desirable; that is, the efficiency that will give the most desirable results.

Now, what are the most desirable results? It is easy to answer this question. Electric lighting is a commercial business, engaged in for the purpose of making money, and the most desirable results are those that yield the greatest net money return; or, briefly, the most desirable results are net earnings. The question reduces itself, then, to what efficiency of lamp in central station service will secure the greatest amount of net earnings.

Before proceeding with the discussion it will be well to have other definitions and agreements clearly stated.

First of all, the lamp unit for the general discussion will be the standard sixteen-candle-power, 100-volt to 125-volt lamp. Other units of candle-power will be considered subsequently.

Second—The efficiency will mean the watts per candle taken by the lamps at starting; that is, the initial efficiency.

Third—The lamp life considered will be what is known as the useful life; that is, the life to the point where the lamp has dropped to eighty per cent of initial candle-power. This conforms to standard practice of the day.

Fourth—The light is assumed to be sold by meter on the kilowatt-hour basis.

Fifth—Lamps are assumed to be supplied, either free or at such a low price to consumer as to give the central station entire control of the matter.

Free lamp renewals is, first of all, standard and accepted practice of the

most successful stations, approved by leading engineers and managers; and the reasons for this were fully given in the paper presented by the writer at your last year's convention. Aside from this, however, free renewals or control of lamps must be assumed if a station is to decide the question of the best lamp efficiency; for without free renewals, or lamps at a very low cost, how can any station secure the use of that efficiency determined as best? Experience has shown that where the consumer buys the lamps, low-efficiency lamps are invariably used, and lamps are never renewed except when broken. We shall later see additional reasons for the necessity of free lamp renewals where a station desires to select and put in service those lamps having the best efficiency for its conditions.

THE COST OF LIGHTING.

The cost of lighting may be divided into two items: The cost of the lamp and the cost of the current; the latter cost can be taken to include all expenses, fixed charges, etc.

USEFUL LIFE AND LAMP COST FOR THE DIFFERENT EFFICIENCIES OF THE SIXTEEN-CANDLE-POWER LAMP.

The cost of lamps varies for a given price of lamp with its efficiency. Assuming that lamps are renewed at the end of their useful life, we have the variation of lamp life and lamp cost per kilowatt-hour for different efficiencies of the sixteen-candle-power lamp given in table I and plotted in the curves of Fig. 1. These values of cost per kilowatt-hour are deduced from the formula lamp cost per kilowatt-hour =

$$\frac{\text{Cost of lamp}}{\text{Efficiency} \times \text{candle-power} \times \text{useful life}}$$

TABLE I

USEFUL LIFE AND LAMP-RENEWAL COSTS PER KILOWATT HOUR FOR SIXTEEN-CANDLE-POWER, 100-VOLT TO 125-VOLT LAMP AT VARIOUS INITIAL EFFICIENCIES.

(Lamps renewed at end of useful life.)

Efficiency in Watts per Candle	Total Watts	Useful Life in Hours	Lamp-Renewal Cost per K.w.-Hour in Cents. (Lamp Price, etc.)	Lamp-Renewal Cost per Kw.-Hour in Cents. (Lamp Price, etc.)
1	33	55	9.35	11.65
1.1	35.6	70	6.8	8.5
1.2	35.2	89	5.13	6.4
2.3	36.8	110	3.95	4.94
2.4	38.4	136	3.07	3.84
2.5	40	166	2.41	3.01
2.6	41.6	200	1.94	2.43
2.7	43.2	236	1.56	1.96
2.8	44.8	282	1.26	1.58
2.9	46.4	336	1.02	1.28
3.0	48	400	0.83	1.04
3.1	49.6	470	0.69	0.86
3.2	51.2	550	0.57	0.71
3.3	52.8	639	0.47	0.59
3.4	54.4	738	0.4	0.50
3.5	56	846	0.39	0.42
3.6	57.6	965	0.29	0.36
3.7	59.2	1090	0.25	0.31
3.8	60.8	1227	0.21	0.27
3.9	62.4	1374	0.19	0.23
4	64	1500	0.17	0.20

IS OPERATING COST THE BASIS?

The question might be asked: Why is not that efficiency the most desirable which secures the lowest operating cost; that is, the lowest cost of lamp renewals and cost of current to the station? The answer is: It would be the correct basis were light sold by the lamp-hour. Here the efficiency of the lamp does not affect the cost of light to the consumer. The central station receives the same return per lamp whether the lamp be of one efficiency or of another, and it is obvious, therefore, that for a given number of lamps, the most profit can be made with that efficiency of lamp which gives the minimum operating cost. This would, of course, be modified somewhat by the consideration of how much additional income could be secured by increase in number of lamps through the use of higher-efficiency lamps.

Electric light, however, is not sold by the lamp-hour, but by the kilowatt-hour. This makes a material difference in results. The efficiency of the lamp now affects the cost to the consumer as well as to the station. The use of a low-efficiency lamp decreases the cost to the station (by reduction in lamp renewals), but it increases the cost to the consumer. With a high-efficiency lamp the case is reversed; the station cost is increased and the consumer's cost is reduced.

It should be here observed that, so far as the station is concerned, having a given output in kilowatt-hours to sell and being paid for it by the kilowatt-hour, it makes practically no difference in the economy of the station whether it is sold in high or low-efficiency lamp units, except in the matter of lamp renewals. The case is quite analogous to the substitution of smaller candle-power than the standard sixteen candle-power, which is the largely accepted practice to-day, and which makes practically no difference in the economy of the station, except as to lamp renewals.

Looking at the question, therefore, from the operating-cost standpoint, the logic of the situation points to the use of the lamp that costs the least for renewals, that is, the extreme of low-efficiency lamps, the limit of which would be a lamp that never burned out. To accept this conclusion, however, we should have to assume that people could not do without electric light and that the station could invariably sell all the current it could generate; in other words, there must be a complete monopoly for electric lighting. Such is seldom, if ever, the case, and we are forced to look at the question from the standpoint of the consumer, whose interest demands a lamp of the highest practical efficiency.

I have heard the argument advanced that a station could reduce its cost by the use of low-efficiency lamps, thereby enabling it to reduce rates and thus stimulate business. Low rates, however, do not give these results unless they secure low costs to consumers. This argument, therefore, is a fallacy, since the slight decrease in rates rendered possible by the reduction in cost of the station supply with a low-efficiency lamp will not suffice to reduce the cost to the consumer because of the increased power to be paid for. In other words, the low-efficiency lamp increases the consumer's bill more than it is lowered by the reduction in rates the station can offer from the savings in lamp renewals.

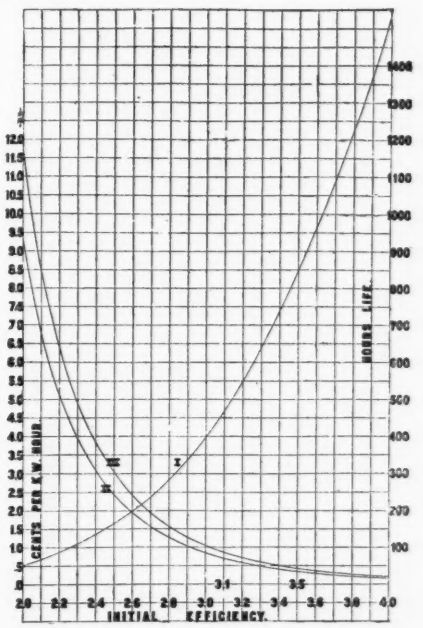


FIG. 1—Curve (I) of useful life of standard sixteen-candle-power lamp at various initial efficiencies. Curves II and III giving cost of lamps per kilowatt-hour for sixteen-candle-power, 100-volt to 125-volt lamps at various initial efficiencies. Renewing lamps at end of useful life. II—Cost for lamp price sixteen cents. III—Cost for lamp price twenty cents.

From curve in Fig. 1 we see that the saving in cost to station of lamp renewals by the substitution of four-watt lamps for 3.1-watt lamps is about fifty-two cents per kilowatt-hour. The increased power to be paid for by consumers is 14.4 watts (sixty-four watts less 49.4), or twenty-eight per cent. On a ten-cent rate this requires a reduction of nearly three cents, which means that the rate reduction must be six times the saving to the station. Obviously, we can benefit consumers more with a high-efficiency lamp at the old rate. If reductions to consumers are necessary, the greatest saving can be made at the least cost to the central station by a slight reduction in rates and the use of a high-efficiency lamp.

The use of four-watt or low-efficiency lamps might be desirable to increase in-

come where very low rates have existed which is not advisable or possible to increase, but purposely to adopt low-efficiency lamps in order that low rates may be made, seems to me like putting the cart before the horse.

The fixing of rates is a large question, and should not be made to revolve about the cost of lamp renewals. Giving low rates with the expectation of making up by the use of low-efficiency lamps is dangerous; it is apt to drive the consumers to supplying their own lamps. This may be thought to be an advantage, but the free-lamp renewal policy is shown by practice and years of experience to be an invaluable essential to good electric lighting service. Nothing should be permitted that jeopardizes it. Furthermore, the employment of low-efficiency lamps is apt to invoke municipal criticism and action and the probable enactment of an ordinance requiring the supply of high-efficiency lamps. Rates once reduced can not well be raised, and down goes the income.

It is generally best to keep rates as high as possible and secure reductions through use of the most efficient devices.

Returning, now, to the general question of the most desirable efficiency, we find, as a general conclusion, that we can not determine it from the standpoint of operating cost, as this basis will not secure the greatest amount of net earnings.

HOW MAY NET EARNINGS BE INCREASED?

In order to arrive at the proper standpoint, it will be well to discuss briefly the general question of net earnings and how they are increased.

Net earnings are the product of per cent of profit by amount of business. There is a point of balance between these two factors at which their product, the net earnings, becomes a maximum.

The largest profits are not secured by exacting the highest per cent of profit, but, on the contrary, are generally secured by low prices and small per cent of profit, thereby increasing the gross business and swelling the total profit. In other words, we are concerned not so much as to the cost of our commodity (costs may be, and frequently are, increased with advantage); not so much with per cent of profit, but chiefly with so fixing the selling price and pushing the business as to increase the sales to the point of securing the maximum profit. Applying this idea to the question of lamp efficiency, we would say that the most desirable efficiency is not that efficiency which gives the lowest cost to the central station, or that efficiency which will return the highest per cent of profit from customers; but rather it is that efficiency which for any given rate will secure to the electric lighting company the greatest amount of profit, swelling the gross profitable business, not only by augmenting the number of lamps connected, but also by increasing the average hours used so as to bring in the fullest net returns.

With the accepted basis of sale of light by the kilowatt-hour, it is plain, as I have already stated, that the efficiency of lamp used makes practically no difference in the economy of operating and service except in the matter of lamp renewals. With the consumer supplying his own lamp renewals, the station would hardly be concerned at all (within extremes) with the question of efficiency. The consumer could use any efficiency (within limits) that he pleased and it would make practically no difference to the central station, which receives its pay for the energy consumed. I say practically no difference, as the station would be concerned to the extent of having its consumers use that efficiency of lamp which would keep the consumer's bill from being excessive. The minimum cost to the consumer would be secured with that efficiency which made the sum of lamp renewals and cost of current a minimum.

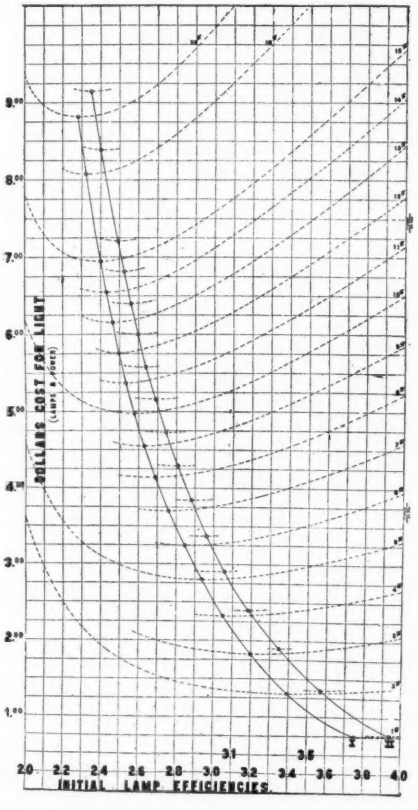


FIG. 2—Minimum cost curves (I, II) giving efficiencies of standard sixteen-candle-power lamp at which for different rates of power and cost of lamps the cost of light is a minimum (renewing lamps at end of useful life corresponding to each efficiency). I—Curves for sixteen-cent lamp price. II—Curves for twenty-cent lamp price. Dotted horizontal curves give total cost of light (lamps and power) at different rates.

THE EFFICIENCY GIVING MINIMUM COST TO CONSUMERS.

The efficiencies at which this minimum cost is secured are given by the curves in Fig. 2. These curves are plotted by taking the minimum points of the curves of cost (dotted curves). These cost curves were deduced for the different power rates from the formula.

Cost of light = cost of power + cost lamp = rate × lamp efficiency × candle-power × hours used + lamp efficiency × candle-power × hours used × cost of lamp per kilowatt-hour.

Since lamps cost per kilowatt-hour = $\frac{\text{Cost of lamp}}{\text{Efficiency} \times \text{candle-power} \times \text{useful life}}$ the formula reduces to

Cost of light = hours used × rate × lamp efficiency × candle-power + $\frac{\text{Cost of lamp}}{\text{Useful life}}$

I have assumed a thousand hours' service as a basis and have deduced from this formula, in conjunction with life values given in Fig. 1, the value of total cost of light for the various efficiencies of sixteen candle-power at practically all the different rates for current and at two costs for lamps—sixteen cents and twenty cents. These values are plotted in the horizontal curves shown in dotted lines. The vertical (solid) lines intersecting the lowest point of these curves are the curves of lamp efficiencies which secure minimum cost of light. For example, with lights costing sixteen cents and at a rate of six cents per kilowatt-hour, the curve shows that an efficiency of 2.9 watts per candle secures lowest cost. With a twenty-cent lamp cost and a ten-cent rate, the curve shows that the efficiency should be 2.75 watts per candle, etc.

The assumption made of the consumer supplying his own lamp renewals is not a true one, as the best practice, and many years of experience of central station service, have fully demonstrated that the station should supply lamp renewals free to the consumer. Free lamp renewals has therefore been accepted as the standard practice; but in any event, as already stated, free renewals, or the control of lamps, is necessary to the purposes of this discussion.

The curve in Fig. 2 shows that for all the general rates of current supply (four cents per kilowatt-hour and above) the minimum cost of service is secured with an efficiency of three watts per candle, or higher. Now, experience has shown that

lamps of an efficiency of 3.1 watts per candle can only be kept in service by supplying lamps free or at a very low figure, well below cost. Some consumers would, of course, appreciate their value, but the average layman can not be made to understand that he is not saving money when he is saving on the cost of his lamps. When the lamp supply is left to him, therefore, the low-efficiency, long-lived lamps prevail and lamps are renewed only when they break.

THE CASE STATED.

So, then, we have our general case summed up as follows:

We have deduced and have before us the efficiency that secures the minimum cost of light to the consumer at various rates, including the cost of lamp renewals. Accepted practice supplies the lamp renewals free and saves the consumer this part of his expense.

What lamp efficiency, then, is the most desirable? Clearly, it should be that efficiency which would, if the consumer bought his own lamp, secure him his light at the lowest cost, or, in other words, the efficiencies that are given by curves of minimum cost in Fig. 2. This is true, because at any lower efficiencies the consumer could afford to buy his own lamps and save money. Here is the point, then, that the station should reach in lamp efficiency.

Referring to the curve in Fig. 2, the two curves representing the two lamp costs of sixteen and twenty cents, and including all rates from one cent to twenty cents per kilowatt-hour, cover quite completely all practical cases. From the values shown by these curves we see that no central station having suitable voltage regulation should use any lower-efficiency lamp than 3.1 watts per candle. It will surprise many, perhaps, to note that it is at the rather low rate of four and five cents per kilowatt-hour, and with a twenty-cent price for lamp that we get a minimum cost with the 3.1-watt lamp and, therefore, that for all higher rates than this lamps of an efficiency of 2.9, 2.8, 2.7, and up to 2.5 watts per candle, become the proper ones to secure minimum cost. It is plain, then, that the 3.1-watt-per-candle lamp, at the least, should be supplied in central station service. Whether a higher-efficiency lamp should be used will depend upon the average of rates given and the special conditions of supply.

We see from Fig. 2 that for rates from eight to twelve cents the 2.75-watt lamp appears desirable; for rates from fourteen to eighteen cents the 2.5-watt lamp is the one, and for twenty-cent rates a lamp between two and one-half and two watts per candle should be used. It must be noted, however, that the conditions of supply come in to modify these results considerably.

Consumers whose average rates are as high as twelve to twenty cents per kilowatt-hour are consumers whose lamps average only about one-half hour to an hour's use per day. They would require, therefore, several years to make the saving shown, which is based on 1,000 hours' service. Such consumers, moreover, are more or less unprofitable to the station, and it would therefore be unwise for the station to increase its cost for such business by adopting a very high-efficiency lamp.

For consumers paying a rate of from eight to twelve cents, the 2.75-watt lamp is the desirable one. Such a lamp in place of the 3.1-watt lamp has already been asked for by some central stations. We may well consider whether it is not time for the adoption of a higher efficiency than the 3.1-watt. Some companies, however, consider a 2.75-watt lamp so close to the 3.1-watt lamp as to invite a compromise. It is plain, therefore, that the 3.1-watt lamp, or better, is the best efficiency for all cases where current is sold for lighting supply. Four-watt lamps and 3.5-watt lamps are not desirable unless the station regulation is not good enough for the use of the 3.1-watt lamp.

In the case of supply of light for the station's own use, or in the case of isolated plants, and in all cases where costs are below three cents per kilowatt-hour, the results point to an efficiency between 3.3 and 3.5 watts per candle as the efficiency giving lowest total cost for light. With power costs below two cents, as in the case of electric street railways, the four-watt lamp becomes the one to use.

THE QUESTION OF REGULATION.

Speaking generally, then, for central station lighting service, the rule appears to be to use the highest efficiency permissible with the voltage regulation.

The question may be asked, How much of a variation of voltage is permissible with a 3.1-watt lamp? The effects of increase of voltage are given in the following table, in which is also given, in the second column, the efficiency at which the lamps burn with the various increases in voltage.

Voltage per cent of Normal	Watts per Candle Power	Life per cent of Normal
100	3.10	100
101	3.00	82
102	2.91	68
103	2.82	56
104	2.73	46
105	2.64	38
106	2.56	32

The reduction in life shown is given only when the voltage is permanently kept high. This should not occur to a greater extent than four per cent, which would allow for an extreme variation several per cent higher. If voltage runs permanently as high as this, or higher, then a higher-voltage lamp should be used.

We see from the foregoing table that with a pressure of four per cent to five per cent high the efficiency is only increased to about 2.75 watts per candle. Reference to our minimum-cost curve (Fig. 2) shows that an efficiency of 2.75 watts per candle is not excessive, but gives minimum values quite closely for the general net rates in use. Therefore, with a regulation running permanently four per cent high we can use the 3.1-watt, sixteen-candle-power lamp and still be within the range of economical results. There should be no good reason, however, for such a permanent excess of pressure, as lamps of higher voltage can readily be obtained to correspond to the higher line pressure.

The average life (lamps left to burn until broken) at 3.1 watts of the sixteen-candle-power lamp is about 750 hours, and from our table of life variation with voltage we can, by sacrificing the candle-power limit, suffer a pressure variation as high as four per cent, reducing the actual life to 350 hours, which is long enough to compensate for the advantages of the 3.1-watt lamp. Good regulation, however, is such a valuable essential that it should be secured and maintained by all stations. Modern automatic voltage regulators like the "Tirrell" render this practical and possible. We see, therefore, that, first of all, regulation has to be very bad to exclude the 3.1-watt lamp, and secondly, that there is no good reason why bad regulation should exist in any station service and that it most emphatically pays to get rid of it.

CONSIDERATIONS IN FAVOR OF THE 3.1-WATT LAMP.

In addition to the considerations we have noted, there are other features that recommend the 3.1-watt lamp. One is the better quality of the light; its greater brilliancy and attractiveness.

The power of light to bring out colors increases with the temperature of the filament, and the 3.1-watt lamp is therefore much better suited than lower-efficiency lamps for modern illuminating work with dry-goods, pictures, etc., in which color effects must be shown as far as possible in their real values.

Another feature is that a 3.1-watt lamp, although giving equal candle-power with lower-efficiency lamps, always looks brighter to the eye, and is on this account a more popular lamp.

(To be concluded.)

SOME NOTES ON EUROPEAN PRACTICE IN ELECTRIC TRACTION WITH THREE-PHASE ALTERNATING CURRENTS.*

BY CARL L. DE MURALT.

There have recently been some pretty lively discussions between the advocates of continuous current and those of alternating-current systems for electric traction purposes.

Now I wish to state right at the beginning that in the opinion of the author there are certain cases where continuous current is preferable and where alternating currents could not do the work as well, on the other hand there certainly are cases where alternating currents are particularly well adapted to solve the problems in question and where continuous current could not be used advantageously. Each special case should therefore be studied for itself, and the decision as to what system should be adopted ought to be dependent on all the different conditions which might apply to the particular case, *viz.*, profile of the road, speed required, number of stops, traffic conditions, etc. Probably most of us will agree, for instance, that, taking everything into consideration, the recent decision in the London underground railway case was really the best solution of this rather complicated problem.

In America continuous-current practice has so far almost absolute sway, and it may therefore be interesting to learn something of what has been done in Europe, and more particularly in Switzerland, in the way of using alternating currents for traction purposes and to hear at the same time something about the practical results obtained on some alternating-current roads that have been in operation several years.

Brief descriptions follow in chronological order of some of the most typical roads of this kind including as many details as possible, especially in regard to the Burgdorf-Thun Railway, probably the best example of an alternating-current railway installation. The results of some tests made on this latter railway are also given with a few general conclusions as to the applicability of polyphase alternating currents for traction purposes.

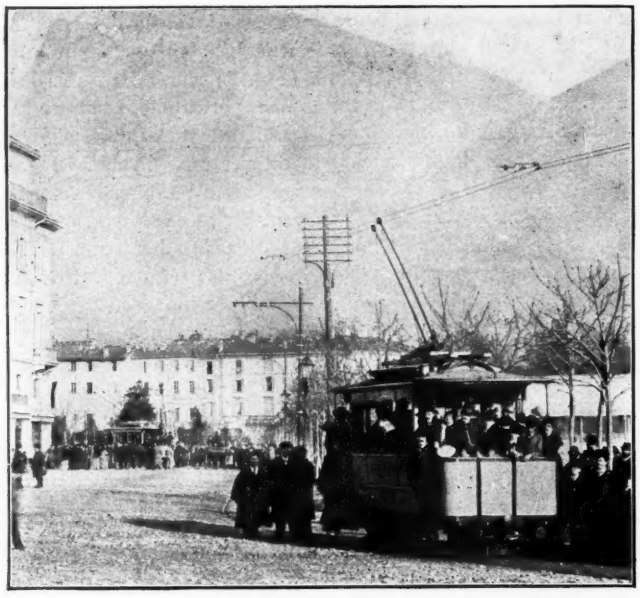


FIG. 1.—CAR AND TRANSMISSION APPARATUS USED ON LUGANO TRAMWAYS.

First Tests by Siemens & Halske—The first tests with alternating-current traction were made by Siemens & Halske, of Berlin, in 1892, in Charlottenburg, on a specially constructed track of about 360 m. length with one curve of 40 m. radius. There were two overhead trolleys, the rails forming the third conductor. The voltage was between 500 and 600, the periodicity fifty cycles per second. An open car was used on an ordinary street railway truck, equipped with a three-phase induction motor driving one of the axles by means of a single reduction gear of 1:11. The speed of the motor being 1,400 revolutions per minute, the maximum speed attained was about 25 km. (fifteen miles) an hour.

The primary winding of the motor was arranged to allow being connected in delta for starting purposes, while it was changed to star connection for full speed. The starting torque of the motor was therefore made about six times the full load running torque. The motor was also provided with slip rings on the rotor which allowed for inserting resistance into the secondary winding.

These tests showed clearly that an alternating-current railway was absolutely feasible, and proved that no serious difficulties would be encountered in regard to the trolley-line construction. However, the street railway problems then under consideration did not absolutely require the use of anything else but the use of the well-known continuous-current system, and this is probably the reason why these tests were not carried any further and put into actual practice.

The installation as just described was sent to the Chicago Exhibition in 1893, where it attracted considerable attention, but nothing has been heard of it since.

Lugano Tramways—Brown, Boveri & Company, of Baden, Switzerland, may claim the honor of first putting alternating current into actual use for traction on a commercial scale. The tramways of Lugano, the first three-phase railway, were opened for traffic in 1895. The power station for these tramways is 12 km.

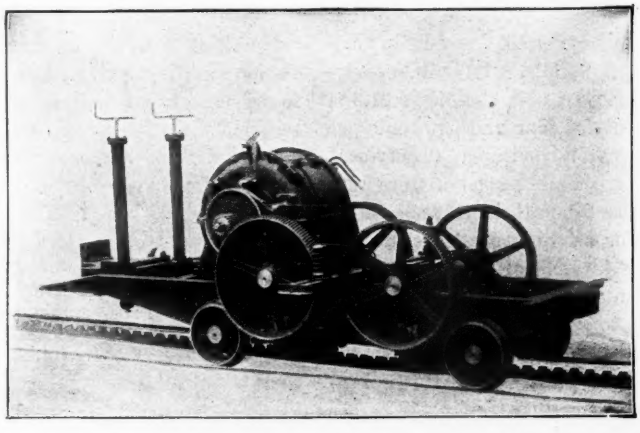


FIG. 2.—TRUCK OF GORNERGRAT LOCOMOTIVE.

*A paper presented before the American Institute of Electrical Engineers at New York, May 20, 1902.

outside of town, therefore transmission with 500-600 volts continuous current was impossible. Rotary converters seemed too expensive, and thus it happened that all conditions were favorable for an experiment with three-phase alternating currents. The total length of the line is 4,900 m. (about three miles) with maximum grades on long stretches of three per cent and on short stretches of six per cent. The transmission voltage is 5,000 volts at forty cycles. Transformers reduce this to 400 volts. Two trolley wires of 6 mm. diameter, 25 cm. apart, are used and the rails serve as third conductor. Cars hold twenty persons each. There is one twenty-horse-power motor per car, completely enclosed, with single reduction gear 1:4. Speed of car 15 km. (9.3 miles) an hour. Two trolleys, one 1 yard behind the other, make contact with the two lines. Motors are started by means of a reversing switch, and their speed is controlled by means of a resistance in the rotor circuit. Cars can be handled from both platforms. Fig. 1 gives a good idea of one of these cars, and shows part of the line. Tests have demonstrated that it is possible to start with ease even on six per cent grades and under more than full load.

Gornergrat Railway—After the Lugano plant had thus proved that alternating currents could be applied to ordinary tramway purposes, the Gornergrat road was destined to show that they could also be used to advantage on a much larger scale and under the most severe conditions met on a Swiss mountain road. The total length of this line is 9 km. (5.6 miles). The difference in altitude of the two terminals is 1,412 m. (4,660 feet). The maximum grade is twenty per cent, the minimum radius in curves 80 m. The gauge is 1 m. (three feet three and three-eighths inches) with an Abt rack between rails. The power station generates 5,400 volts at forty cycles. Three transformer stations of 180 kilowatts each, 2, 5 and 8 km., respectively, from the beginning reduce from 5,400 to 540 volts. The high-tension line follows a separate route. The trolley line consists of two wires of 8 mm. diameter suspended by means of cross-wires from wooden poles every 25 m., the rails forming the third conductor. The speed is 7 km. (4.35 miles) an hour, and there are five stations, 2.5 to 3 km. (1.5 to 1.8 miles) apart. The normal train consists of one locomotive, one main passenger car (sixty persons) and one second car (fifty persons) added when needed. As a maximum there are two trains up and one down on the road at the same time. The locomotive weighs 10.5 tons, two cars 9.2 tons and 110 passengers 8.3 tons, total for one train twenty-eight tons. The motor capacity is therefore 160 horse-power or about 180 horse-power on axles,

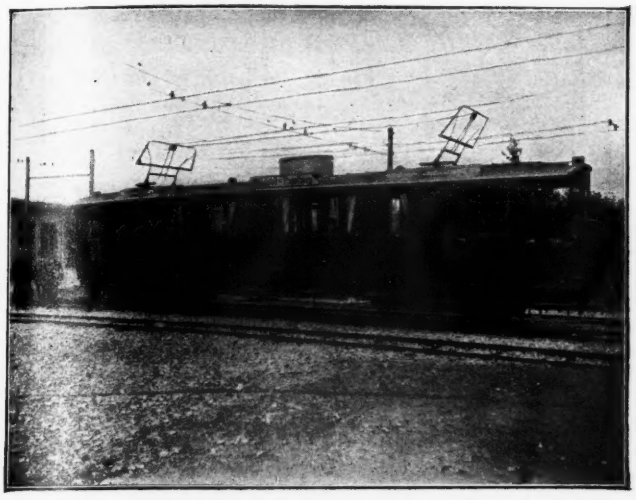


FIG. 3.—DOUBLE CONTACT TROLLEY CARS ON STANSSTAD-ENGELBERG RAILWAY

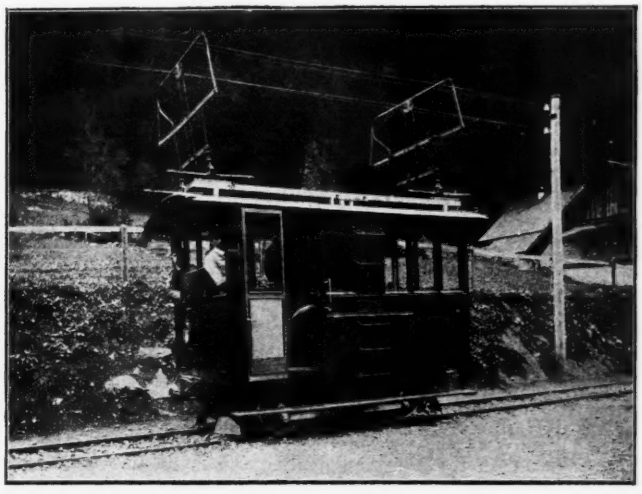


FIG. 4.—LOCOMOTIVE ON STANSSTAD-ENGELBERG RAILWAY.

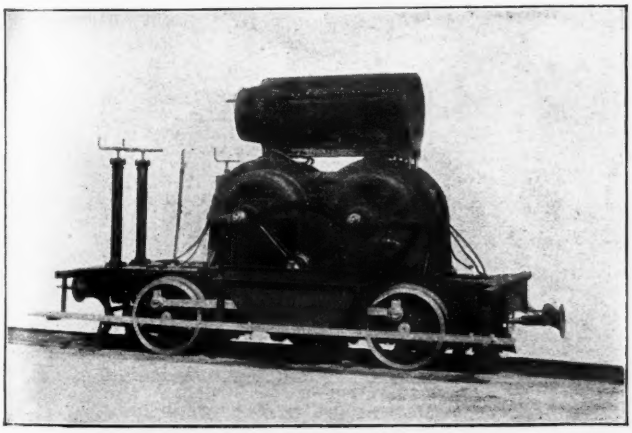


FIG. 5.—INTERIOR VIEW OF LOCOMOTIVE, STANSSTAD-ENGELBERG RAILWAY.

FIG. 6.—LOCOMOTIVE AND PASSENGER CAR, TWENTY-FIVE PER CENT GRADE, STANSSTAD-ENGELBERG RAILWAY.

and the locomotive is equipped with two motors of ninety horse-power each, running at 800 revolutions per minute. Each motor drives by means of a double gear one of the two cog-wheels. The total reduction of gear is 1 : 12. The motors are controlled by a reversing switch through which the stator is connected to the line and by the usual starting rheostat in the rotor circuit. The rheostat is placed on the top of the motors to save space, and the switch, fuses and instruments for the same reason on the side and against the roof of the car. Two trolleys are employed on each line wire on account of the large current and in order to pass switches without making a break. The motors start on any grade under full load without using more current than when running at full speed and full load. They can start under more than full load, but with proportionately more current. Fig. 2 shows the truck of the Gornergrat locomotive with one of the motors in its place. This line was completed in 1897 and opened to traffic in 1898.

Jungfrau Railway—Before it was finished, work was already begun on a very similar line, the Jungfrau Railway. The total length of this road is 13 km. (eight miles) with a difference in altitude 2,100 m. (6,900 feet). The grade, almost immediately after leaving the little Scheidegg station, is ten per cent and this is increased to twenty per cent at about half way to the Eiger Glacier Station. From there on, the grade increases to the maximum of twenty-five per cent when the line enters the tunnel. The permanent way is of metre gauge with a rack of the Strub system half way between the rails. The sharpest curve on the open section has a radius of 100 m., in the tunnel this is increased to 200 m. Water power is made use of in the valley of the White Lutschine to generate three-phase currents at 7,000 volts and thirty-eight cycles, which is transmitted by overhead wires to transformer stations along the line, where it is transformed down to 500 volts. The substations are stone buildings, designed to withstand the action of the most inclement weather. They are fitted each with two 200-kilowatt transformers. When the whole line is completed, transformers will be placed about every 1,000 yards. There is a double trolley line as on the Gornergrat. The locomotives are very similar to those on the Gornergrat line. They weigh thirteen tons complete, and contain each two 125 to 150-horse-power induction motors, driven at 760 revolutions per minute. The motor controlling devices and the contact arrangements are exactly the same as on the Gornergrat road. The cars hold forty persons each and a normal train consists of one locomotive pushing two cars, the total weight of such a train, when filled, being twenty-eight tons as on the Gornergrat road. The speed, however, is 8 km. (five miles) per hour.

The first section of the Jungfrau Railway to Eigergletscher was opened in September, 1898, the second to Rothstock in April, 1899, since then each year has seen further progress toward the summit, which will probably be reached in five or six years.

Stansstad-Engelberg Railway — The next alternating-current railway to be built was the one from Stansstad to Engelberg. This road, although of metre gauge only, approaches in the shape of its cars normal gauge railway conditions. The total length of the line is 22.5 km. (fourteen miles). The first 15 km. have small grades up to two per cent, the next three km. have grades of 2.5 to five per cent, then follows a section of 1.5 km. long with a grade of twenty-five per cent and a so-called ladder rack, finally about 3 km. more with grades of 2.5 per cent and less. The minimum radius in curves is 50 m. The power station is

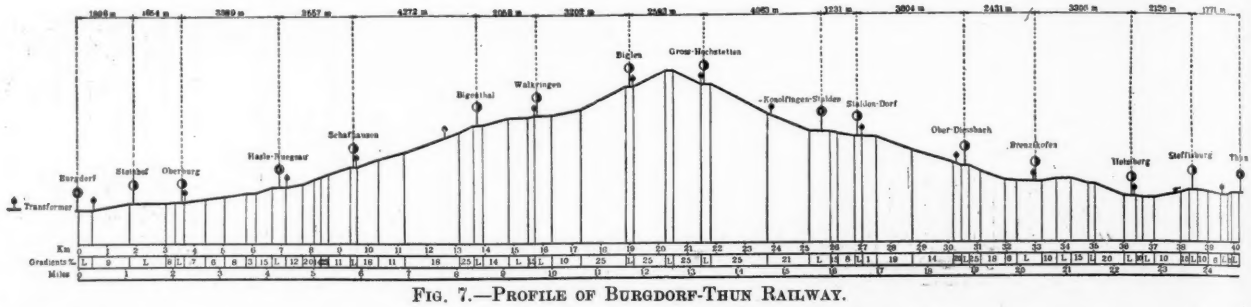


Fig. 7.—Profile of Burgdorf-Thun Railway.

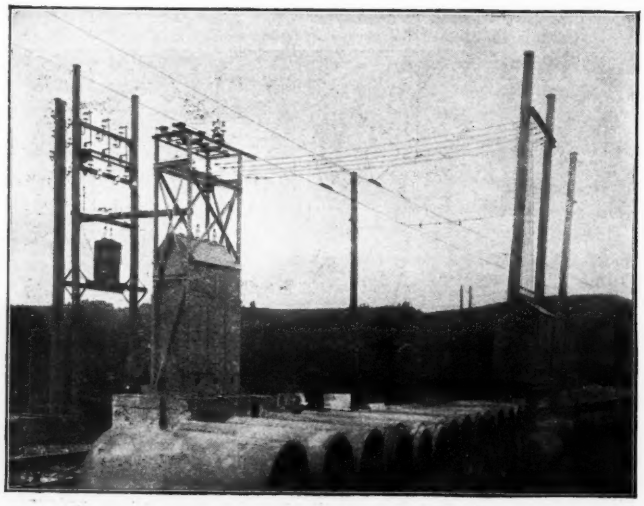


Fig. 8.—Transformer Substation, Burgdorf-Thun Railway.

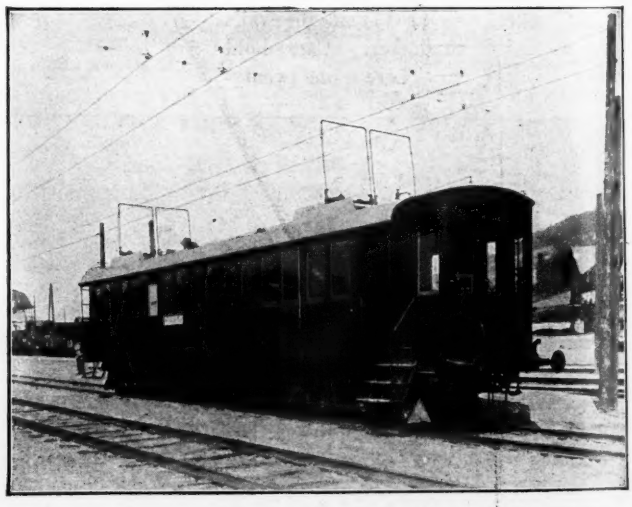


Fig. 9.—Contact Devices on Car, Burgdorg-Thun Railway.

situated at the begining of the rack section, about 18 km. from Stansstad, therefore it is near the point where the maximum energy is used. The voltage generated is 750 volts at 32.5 cycles, and this is fed direct into the trolley line. A ninety-kilowatt step-up transformer produces 5,300 volts which is transmitted to two substations situated about 3 and 7 km. respectively from Stansstad and containing each a similar transformer, reducing the voltage again to 750 volts. The trolley line construction is similar to that found on the Gornergrat and Jungfrau railways. There are nine passenger stations on this road. Three locomotives and seven motor passenger cars are used. The cars shown in Fig. 3 are of the double truck type, and their total length is 14 m. Each car weighs fourteen tons and has room for forty-six passengers besides being provided with a baggage compartment. The front truck carries two motors of thirty-five horse-power each, running at 400 revolutions per minute, with single reduction for a car speed of 20 km. (12.5 miles) per hour. The contact with the trolley line is made by means of two double contact bars attached to the roof near each end of the car. The cars can be controlled from either end-platform and the control is similar to that already described for the other roads. One automobile car is able to propel itself and to haul a trailer of about ten tons on grades up to 2.3 per cent. The first 15 km. section which happens to have the heaviest traffic is therefore worked with two cars at a speed of 20 km. per hour. The next section with heavier grades up to five per cent is traversed by the motor car alone at the same speed, the motors furnished about eighty-ninety horse-power for a sixteen-ton load on a five per cent grade. At the beginning of the rack section a locomotive is added which pushes the car up the grade of twenty-five per cent at a speed of 5 km. an hour. The last stretch with grades up to 2.5 per cent is covered by the automobile alone. The locomotive not only serves for the above mentioned purpose but is destined also to haul freight trains of twenty tons total weight over the lower part of the road at a speed of about 11.5 km. an hour. Its design, therefore, varies greatly from the Gornergrat and Jungfrau locomotives. Two motors of seventy-five horse-power each and 650 revolutions per minute drive through a single reduction gear a counter-shaft, which by means of two symmetrically placed gears drive the cog-wheel placed in the centre of the locomotive. This wheel is mounted on a hollow shaft fitted over the crank shaft which in its turn drives the four main carrying wheels of the locomotive. On the rack section the cog-wheel alone is driven. In the level country a friction coupling is set in such a manner that the two main axles are driven and the cog-wheel is allowed to follow loose. The contact device is similar to the one on the passenger cars. Fig. 4 gives a good idea of this locomotive and Fig. 5 shows an interior view of its mechanical arrangement, while Fig. 6 represents a locomotive pushing one of the passenger cars up the twenty-five per cent grade. The Stansstad-Engelberg Railway was opened also during 1889.

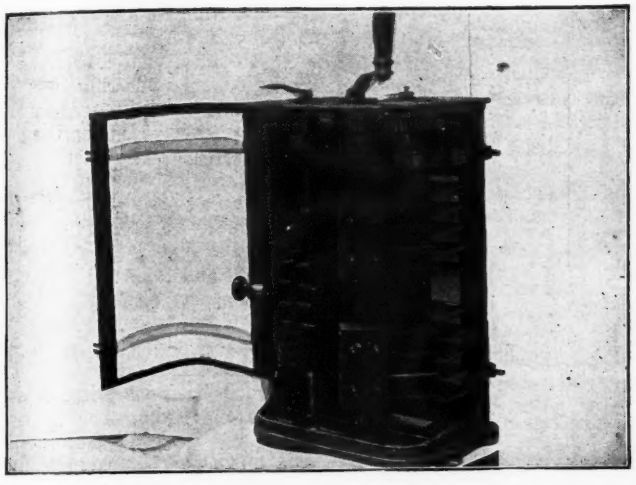


FIG. 10.—CONTROLLER.

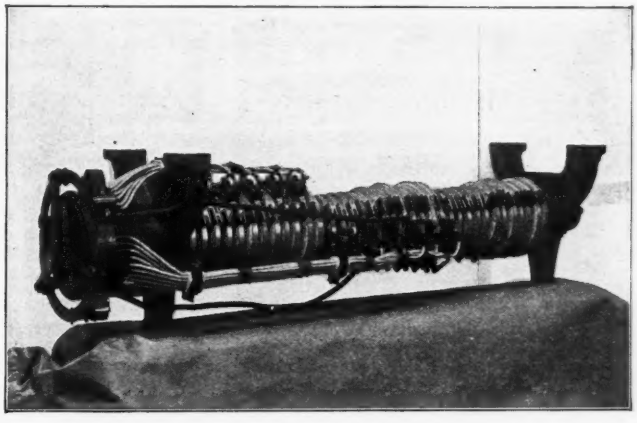


FIG. 11.—CONTROLLER RHEOSTAT.

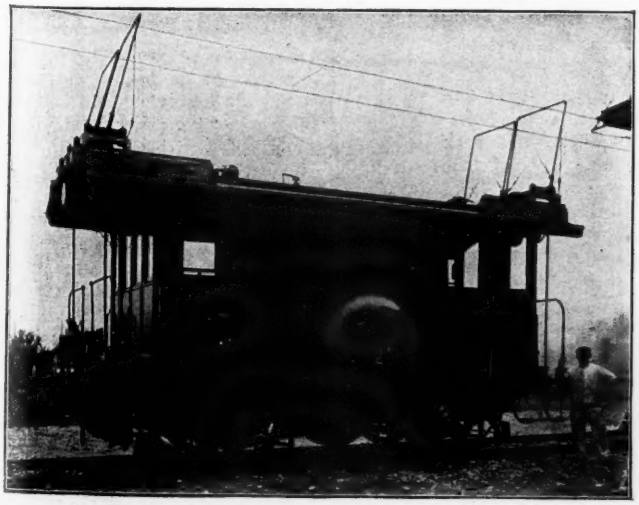


FIG. 12.—FREIGHT LOCOMOTIVE, BURGDORF-THUN RAILWAY.

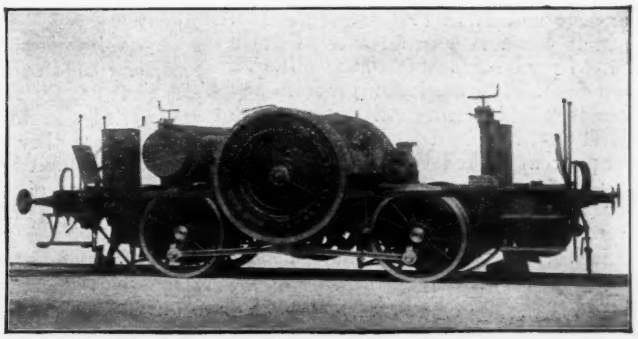


FIG. 13.—INTERIOR VIEW, FREIGHT LOCOMOTIVE.

Burgdorf-Thun Railway—The Burgdorf-Thun Railway, which was opened in 1899 and which will be described more

in detail, is not exactly what you would call a trunk line. Yet it is of normal gauge and forms a very important link between three of the main steam lines of Switzerland. The service conditions are the same as encountered on the other Swiss railways, and it uses the same size and shape of rolling stock as the main steam roads. The total length of the line is 40.3 km. (twenty-five miles). The main reason for adopting electric traction was that the time-table could be arranged much more conveniently than for steam traction. With steam there would have been five trains per day in each direction, costing per year at the least 52,000 francs for coal alone, and each additional train would have cost 10,000 francs more for coal alone. Now, 50,000 francs allows with electricity as motive power the running of ten passenger and two freight trains per day in each direction over the whole length of the line, and besides three or four trains per day from Thun to Konolfingen and back. Each train consists normally of one motor car and one or two trailers with a total seating capacity of 130-140 passengers. This means that not only is the public benefited by a better service, but the number of passengers actually carried is larger and thus increases evidently the income of the railway by a handsome percentage. Fig. 7 shows a profile of this line.

There are sixteen stations, four of which have connections with existing steam lines.

The gauge is normal = 1.435 m., the minimum radius in curves is 250 m.

The road starts at Burgdorf (536 m. above sea) and ascends with an average grade of 1.144 per cent to the highest point almost exactly half way between Burgdorf and Thun (770 m. above sea). Then it descends with an average grade of 1.051 per cent down to Thun (561.5 m. above sea). The maximum grade in any place is 2.5 per cent. All stations have a level stretch at least 200 m. long; sixty-four per cent of the total length is straight line; thirty-six per cent curves; twenty-four per cent level; 23.5 per cent on grades up to one per cent; 31.5 per cent on grades between one and two per cent, and twenty-one per cent on grades between two and 2.5 per cent. Rails are 12 m. long and weigh 36 kg. per metre; forty-five per cent of the track is on iron sleepers weighing 137 kg. per metre track; fifty-five per cent on wooden sleepers weighing 145 kg. per metre. The normal speed was fixed at 39 km. (24.2 miles) per hour.

The energy is furnished by the power station on the Kander, about 10 km. (six miles) beyond Thun. The primary line voltage is 16,000, the number of cycles forty per second. Fourteen transformer stations reduce this voltage to the voltage in the trolley lines which was fixed at 750 volts, this being the limit set by the federal authorities at that time. This voltage, however, seems to be increased slightly in actual practice.

The number of transformers along the line was determined by the following considerations.

The distance between two transformers along the line had to be chosen so that the drop in the line voltage did not exceed a certain predetermined value. On the other hand it was desirable to keep the number of stations within a certain limit in order to make the proportion between installed and actually working transformers as favorable as possible. It will be noticed that at any time only those transformers between which trains are actually circulating are under load, while the rest are not doing any work. Finally the transformers should be placed as near the railway stations as is practicable so as to facilitate their inspection. These somewhat conflicting conditions led to the adoption of fourteen transformer substations with an average interval of 3 km. from one another, the maximum interval being 3.4 km., the minimum 2.4 km. The two end transformers are 500 m. from the terminals of the line.

The size of each transformer would really be dependent on the grades in its vicinity. As these grades are pretty nearly alike in this case, the capacities of the transformers worked out to be very much the same also, and it was therefore decided to use one size of transformers only with a maximum output of 450 kilowatts. This is the power required to move two complete trains. Fig. 8 shows one of the transformer substations.

The high-tension line first passes an emergency switch which permits cutting off the whole station. The transformer is placed in a small iron house containing in its upper part primary and secondary fuses; there is also a lightning arrester on the top of each station. The transformers are of the oil-cooled type and transform from 16,000 volts down to 750 volts. On the secondary side one pole is connected to earth, *viz.*, to the rails, and the other two are carried over to the other side of the track, where they enter a special little switchboard placed in an iron box which allows cutting off the transformer from the line or else either of the two line sections meeting here from the transformer. The whole length of the line is thus effectively cut up into fifteen sections. The secondary box also contains a secondary lightning arrester. Most of the substations are also equipped with a small two-kilowatt lighting transformer, furnishing the current for lighting the neighboring railway station.

The trolley line consists of two copper wires of 8 mm. diameter suspended by means of steel cross wires from wooden poles placed on both sides of the track. These poles are normally about 35 m. apart somewhat less in curves and grade crossings. The height of the trolley wires above the rails is 5.2 m. (sixteen feet) at the most, and at least 4.85 m. The rails form the third conductor and are bonded by means of a special metallic paste.

The contact devices of the cars consist of four steel frames per car as shown on Fig. 9, two on each end of the car roof at a distance of about 9.5 m. (thirty-one feet) from the other two, the contact bar being a brass roller of special shape. This double set was found to be necessary in order to facilitate the passing of switches without breaking the current. At the switches, the two outer trolley wires are carried right through, while the two inside ones terminate in insulated sections prolonged into a common meeting point and there anchored by insulated guy wires. The distance of 9.5 m. between the two sets of contact devices is just long enough to allow three of the four bars making contact under any condition. There is, therefore, no sparking at switches, and it is possible to stop a car underneath a switch and to start it again in the same or the opposite direction.

The are two kinds of motor cars, the passenger automobile and the regular locomotive for freight trains. If this railway had been entirely independent the passenger trains would perhaps consist of one car alone. As it is, the traffic to be handled at the stations having connection with the steam roads necessitated larger carrying capacity of all the trains. The normal train composition comprises one motor car weighing thirty-two tons, capable of pulling a weight of about 20-24 tons in trailers on all grades and at normal speed. The motor car has seats for sixty-six passengers and the trailers for 60-70 more, making a total seating capacity for between 130-140 passengers.

A general view of a motor car is given on Fig. 9. It is a double bogie car with a sixty-four horse-power three-phase motor geared to each axle. The gear ratio is 1 : 3 and the speed of the motor 600 revolutions per minute, equivalent to a train speed of 39 km. (24.2 miles. The four motors are connected with their stators in parallel. The line current passes first through one of the two controllers, placed one on each car platform, then through automatic cutouts to the motors. The first motion of the controller handle closes the switch shown on Fig. 10 and connects the stators to the line, at the same time cutting in four rheostats, one into each rotor circuit. Subsequent turning of the controller handle works a combination bevel and chain gear through which three carbon brushes are moved on a sort of commutator attached to each rheostat (see Fig. 11) whereby all the resistance is gradually taken out and the rotors left short-circuited. A second handle on the controller reverses the direction in which the car is going by changing two of the main leads. Each car platform is equipped with two ampere-meters, one voltmeter and a recording tachometer. A Westinghouse brake and an electric lighting and heating installation complete the equipment.

(To be concluded.)

The Electric Light Convention—II.

The Twenty-Fifth Convention of the National Electric Light Association at Cincinnati, Ohio.

IN THE last issue of the ELECTRICAL REVIEW the proceedings of the first day of the convention were given with great fulness. In the following pages will be found an extended report to supplement the telegraphic report of the proceedings of the second and third days printed last week.

WEDNESDAY MORNING, MAY 21.

President Doherty called the meeting to order at 10.10 A. M.

A number of topical questions were first considered.

Mr. B. A. Behrend, of Cincinnati, and Mr. Charles F. Scott, of Pittsburg, then read papers entitled "Three-Phase *vs.* Two-Phase for City Distribution." Mr. Behrend's paper will be found in full on page 708 of this issue. Mr. Scott's paper is given below:

"CHARACTERISTICS OF TWO-PHASE AND OF THREE-PHASE SYSTEMS FOR GENERAL DISTRIBUTION."

(*Abstract.*)

It is a significant fact that as the result of the evolution which has taken place during the last dozen years in electrical systems for general city distribution, the type of generator which is most widely used is the polyphase alternator. This is the case whether the current is to be used ultimately as polyphase alternating current, as single-phase alternating current or as direct current, either for incandescent or arc lighting, for stationary motors or for street railway service. It has not been an unusual thing to find stations in which small engines drive series arc machines for arc lighting, other engines drive direct-current generators for 220-volt, three-wire lighting and power, other engines drive 500-volt direct-current generators for railway service or stationary power, and still other engines drive alternators for furnishing light and power to outlying districts. In the modern station all these different kinds of electrical activity are operated from large economical engines driving polyphase alternators.

While there is practical unity of opinion that the generator should be a polyphase alternator, yet the conditions which determine whether a given alternator should preferably be of the two-phase or of the three-phase type are not fully understood. The question is one which has at times aroused a considerable interest and in the discussion which has taken place upon the subject the ardor of the advocates has sometimes exceeded their technical knowledge of the subject.

The meaning of the terms single-phase, two-phase and three-phase is well known. A simple illustration which shows the relation between the several arrangements may be cited. If two exactly similar armatures for delivering single-phase current be placed with their windings exactly in line upon a common shaft, and if these armatures be surrounded by similar fields which are not in line, but have the poles of one field placed in an angular position midway between the poles of the other field, then the single-phase current which is delivered by the second armature alone does not correspond in its time or phase relation with that of the first armature, but the maximum value of this electro-motive force will occur midway between the maximum electro-motive forces of the first armature. The two single-phase currents considered together are suitable for supplying a two-phase system. If, instead of two armatures and fields, there were three, with the armatures in line and the fields displaced so that the angular interval between field-poles is one-third instead of one-half of the pitch angle between two poles, then the three currents having their maximum values at equal intervals are suitable for supplying a three-phase system. An analogy between the single-phase, two-phase and three-phase currents is found in the single, double and triple-crank engines.

The choice between two-phase and three-phase is not dependent so much upon their abstract and theoretical characteristics as it is upon the actual differences in the characteristics of two-phase and three-phase apparatus, which may exist in the generators, the transformers, the motors and in other apparatus. For example, with certain types of generators there may not be the same reason for choosing one number of phases that there may be with another type. On the other hand, as current may be used in one way in one place and in another way in another place, it may be best to select two-phase generators in one case and three-phase generators in the other case, although the two generators may otherwise have substantially the same characteristics. The problem then is to determine what differences there are in apparatus and in its operation under different conditions between the two-phase and three-phase system and to determine which, on the whole, is preferable under given conditions.

Polyphase load—as distinguished from single-phase load—is quite indifferent as to whether the current be two-phase or three-phase. That is to say, alternating-current motors, whether induction or synchronous, and rotary converters may be constructed for two-phase or for three-phase without any appreciable difference in either the cost or the performance of the machines. Likewise, alternators which supply current to motors and rotary converters in which case each phase is equally and similarly loaded, may be wound for either two-phase or three-phase without any appreciable difference either in cost or in performance. It follows, therefore, that when polyphase alternators supply current to polyphase apparatus any choice which there may be between two phases and three phases must be based upon features which lie outside of the machinery.

The transmission circuit is the important additional element. It is well known that with a given maximum electro-motive force between wires a given power can be transmitted over three wires by three-phase current with the same loss that occurs with four wires when two-phase current is employed. The three-phase current therefore effects a saving of one wire of twenty-five per cent over two-phase. The relative importance of this saving depends upon circumstances, if the distance be long it is considerable, if the distance be short it may be a matter of relative insignificance.

The transformers which may be required between apparatus and transmission circuit in certain ways favor two-phase and in other ways three-phase. The two transformers for a two-phase circuit are obviously of less cost per kilowatt and of higher efficiency and closer regulation than the three transformers of lesser size which would usually be used for the same aggregate output on a three-phase circuit. It is true that two transformers on two phases of a three-phase circuit may be used, but besides the objection to an unsymmetrical or an unbalanced arrangement is the less effective operation of the transformers.

For supplying current to a three-phase motor or rotary converter by two transformers connected on two of the phases it is necessary that the normal output of the transformers should be increased by approximately 17 per cent above what would otherwise be required due to the fact that the two transformers do not operate efficiently for delivering current to the third phase. For example, if 600 kilowatts are to be delivered, three 200-kilowatt transformers, one on each phase, would be the ordinary arrangement. If only two transformers are used, 300 kilowatts each would be the required output if the transformers operated effectively, but when they are connected on two of the phases the size should be increased by seventeen per cent, making about 350 kilowatts. In other words, each of the two transformers for supplying one-half of the 600 kilowatts when connected to two of the phases of a three-phase circuit has currents flowing in its coils which are equal to those which would flow if the transformer delivered 350 kilowatts to a single-phase circuit. It may be observed that if three transformers, each of 200 kilowatts, one on each phase, are arranged for normally delivering 600 kilowatts, and if one of the transformers is out of service, the other two can deliver power to a three-phase circuit, although the output will be reduced to less than 400 kilowatts, namely, about 350 kilowatts or sixty per cent of the output of the three transformers. These transformer relations are not of very great importance and in general do not determine the choice between one system or the other.

Switches and switchboard instruments differ slightly for two-phase and for three-phase circuits. Measuring instruments are usually simpler and more straightforward in their indications on a two-phase circuit than on a three-phase circuit. In conclusion, therefore, when polyphase load such as motors or rotary converters is to be served the most important item in making a choice between the two systems lies in the transmission circuit and the saving of conductors by the use of the three-phase system renders its selection advisable in most cases.

Single-phase load—such as is common with incandescent lighting and arc lighting—involves considerations which do not apply to polyphase loads. When the several circuits from a polyphase alternator supply independent single-phase circuits these circuits are liable to be unequally loaded. The effect of unequal loads upon the several phases is that the voltages on the different phases will differ. In general the single-phase circuits are used for lighting in which it is particularly desirable that constant voltage should be maintained.

The voltage on a single-phase machine may be controlled and properly adjusted by means of a rheostat in the field circuit of an alternator. In the same way the voltage of a polyphase alternator may be raised or lowered, but changes in the field obviously do not afford a means of independent adjustment of the voltage on the several phases or circuits of the armature. Variations in the field current will produce corresponding variations in the voltage on all of the circuits. For this reason it is important that unequal load on the several circuits should produce as small difference in voltage as is possible.

In a two-phase alternator the voltage on each phase is nearly independent of the load on the other phase. Consequently a change in load on one phase has but little effect upon the voltage of the other phase. In a three-phase alternator, on the other hand, load on one phase does affect the voltage on the other phases. One of the peculiarities of this interrelation is that a change of load on one phase acts differently on the voltages of the other two phases, usually raising one and lowering the other. Again, when one

phase is not loaded and two of the phases are equally loaded the voltages on the latter are not equal but may differ considerably. A change in the load of one phase generally affects the voltage of each of the other phases and affects them unequally.

The importance of the foregoing considerations depends to a large extent upon the regulation characteristics of the alternator itself. The per cent by which the voltage of an alternator increases when load is thrown off (the speed and field excitation remaining constant) is termed its inherent regulation. The closer the inherent regulation of an alternator the less is the difference in voltage between the several phases when they are unequally loaded. It follows therefore that close inherent regulation is particularly desirable where unbalanced loads are likely to occur. An alternator of very poor inherent regulation, which might suffer a change in voltage of twenty or thirty per cent when load is removed, may be compensated by auxiliary external means for adjusting the field current so that the voltage will be constant for small loads and for heavy loads. It is necessary, however, that the several circuits from such a polyphase alternator be equally loaded, and it is impossible by any kind of field regulation to secure equal voltages when the circuits are unequally loaded. This type of machine therefore is one which is not at all suited to the independent loading of the several circuits such as is common in stations which have single-phase circuits for incandescent and arc lighting. The inherent regulation of small alternators is not as good as that of large alternators. The division of a number of single-phase circuits between the two phases of a two-phase generator is more readily and simply accomplished than the division among the three phases of a three-phase generator. This is a matter of some importance, particularly in connection with small stations.

Single-phase lighting circuits may be operated from one phase only of polyphase alternators. The other phases may remain idle or may supply other kinds of load where exact regulation is not of great importance, such, for example, as arc lighting, or all the phases of the alternator may supply current to polyphase load. Under these conditions the field current may be adjusted to give the proper voltage on one of the phases without respect to other voltages.

When one phase only of a polyphase alternator is loaded, the output is less than when all phases carry an equal portion of the load. The load which may be carried on one phase is dependent in most cases upon the temperature. If the heat in an armature coil is confined by the insulation, so that it is not readily conducted away, then the current permissible in this coil is not dependent upon the current in other coils.

In the closed coil windings of both the three-phase and the two-phase armatures all of the coils carry current when single-phase current is delivered, whereas in the open coil armatures a part of the coils are idle when single-phase current is delivered.

When the total heat produced in the armature windings is considered, the several types of winding are found to be on a par, although the two-phase closed coil winding still possesses an advantage in that the heating is equally distributed through all the windings, while in the other cases some of the coils are entirely idle or carry only a small current while other parts of the windings carry more than their normal current.

The transmission circuit must also be considered when unbalanced loads are to be carried by a polyphase generator. The circuits from a two-phase generator may be run independent of one another, having separate wires, without mutual induction between the circuits. A greater or less current in one circuit does not directly affect the voltage of a second circuit. The three circuits from a three-phase generator likewise do not affect one another, provided each circuit has its own separate conductors so that three feeders, one from each of the three phases, each has its own two wires, thereby making six wires in all, and effecting no saving in copper over two feeders. On the other hand, in the three-phase, three-wire circuit, the current flowing to the load on each phase affects the voltage in each of the three phases.

The consequence of this close interrelation between phases is that a change of load on one phase affects the drop in each of the other phases and by unequal amounts. For this reason very great precautions are sometimes taken to avoid unbalanced load. The three wires of the three-phase circuit are carried throughout the whole system and incandescent lamps are grouped in threes, one on each phase.

Feeder regulators, consisting usually of transformers of variable ratio by which the voltage may be raised or lowered, are in general use. Such a regulator on a single-phase feeder from a two-phase or a three-phase alternator may raise or lower the voltage of that feeder without affecting the voltage on other feeders. On a three-phase three-wire feeder, however, a regulator in one phase does not limit its action to that phase only but affects one or both of the other phases. If such a feeder has regulators in each of the three phases it is obvious that skillful manipulation of the try, try again kind is necessary to obtain proper voltage on each of the phases on which the loads are independently varying as a change of any regulator affects more than one voltage.

The transformation from two-phase to three-phase and *vice versa* by a main and a teaser transformer is interesting to consider in relation to regulation. If two-phase circuits are supplied from transformers there is substantially the same independence between phases, whether the alternator and transmission circuit be two-phase or three-phase. That is to say, a three-phase alternator and a three-phase line regulate as a two-phase generator and a two-phase line if the load be on two-phase circuits. The advantages of three phases may therefore be secured in transmission, while two phases are employed in distribution. In some long-distance transmission plants the three-phase current is used as three-phase current for polyphase power, such as rotary converters and is transformed to two-phase current for lighting distribution.

The importance which attaches to the unbalance of voltage between different phases and the effect of load upon one phase upon the voltage on other phases is obviously dependent upon the difference in voltage which will be produced under operating conditions. This in turn depends quite largely upon the size and output of generator. The closer the inherent regulation of the generator the less will be the unbalanced condition. Again, the difference in voltage depends upon the amount of unbalanced load. If the conditions are such that the amount of unbalanced load is relatively small or if a good proportion of the load is polyphase load which will be balanced, then the difference in voltage will be small.

A further matter has not yet been given consideration. It is the method of running secondary circuits for serving both light and power. Circuits of this kind will, in general, be operated from larger plants. In small towns the service is usually distributed directly from the transformers without secondary mains, and, in general, separate transformers are supplied with motors.

Three-phase secondary circuits may be operated at 220 volts, with a neutral wire which differs in voltage from each of the others be approximately 125. Motors may be connected to the three main wires and lights between the neutral and other wires.

In general, it is for the engineer, after a careful consideration of the characteristics of the apparatus and the requirements of the service, to determine what is best adapted to meet the conditions in the different cases which arise.

Mr. Behrend opened the discussion. He said: I can not refrain from expressing my appreciation of the views which Mr. Scott has laid before you. I feel especially gratified that the views which come from such a high authority should so closely coincide with my own ideas on the subject. As my paper was very short I will take the opportunity of commenting on a few points which Mr. Scott brought out in his paper. I find that Mr. Scott agrees with me that small machines should be single-phase, large machines two-phase and still larger machines three-phase. As regards three-phase machines, I wish to emphasize a point which I did not bring out clearly. By three-phase has always been understood three-phase, four-wire primaries—of course, only for lighting distribution. There is one point I think which might be of general interest to you gentlemen here and that is the point of margins in generators, the point of inherent regulation. We designers of alternating-current apparatus know that the question of regulation determines not only the design of the machine, but also the cost of the machine. In our specifications for generators it often happens that regulation is specified in a manner which it is next to impossible to check by experiment. I should perhaps say that any written specifications sent out should specify not only the volts in per cent, not only the rising voltage, but should also specify the short-circuit current of the generator for full normal excitation or for normal no load. The short-circuit current is the better check, although I do not want to say it is a perfect check, but it is better than anything else for the determination of your voltage drop of regulation, and it seems to me the customer is better able to judge of that. If you have a lot of rotary converters then the question of regulation is unimportant; but my point is not so much to call attention to differences in design as to call your attention to the absolutely essential fact of stating what regulation you want to have on your generators, and how that regulation is to be tested when it comes to making the actual test.

There is another point to which I would like to call your attention and that is the question of margin. If a man buys a steam engine of 2,000 horse-power to drive his mill, he expects, at certain periods when some of his machinery breaks down, that he will be capable of using that 2,000-horse-power engine for a 3,000-horse-power engine for a short period; in other words, he expects a margin of power. This point is only slowly being understood.

Mr. P. Junkersfeld, of Chicago, said: In this interesting discussion there is one point I think would be of special interest to central station men, the men who have to take the responsibility for a large investment and have to make returns on that investment. The two gentlemen who have spoken agreed that there was really very little difference between the two-phase and three-wire three-phase. My remarks will apply to the four-wire three-

phase. In the four-wire three-phase as it is connected up we have a potential of 2,300 volts between the neutral and the outside wire. It is used for single-phase lighting, using the standard transformer. On the three outside terminals we have 4,000 volts. This machine lends itself readily to transmitting current at 2,300 volts. With the smaller station, it seems to me, in laying out a new plant, the central station man can not afford to overlook the fact that he must be ready to take any business that comes his way. His mission is to build up a large plant, but he should look ahead, even at a little temporary sacrifice. In the majority of cases I do not think it would be even a temporary sacrifice. I think the four-wire three-phase can be placed on an equal basis with the two-phase, even with a small installation. Motor regulators are necessary if good lighting service is to be given, two-phase or three-phase.

Mr. P. A. Bertrand, of Peoria, Ill., said: The matter referred to comes in connection with three-phase secondary distribution, using four wires, as has been noted here; this connecting motors from the three outside wires, and light from either of the three outside wires, or neutral wire. It is cumbersome, however, to put in transformers and to use single-phase transformers, for the reason you have to operate small units.

Mr. R. S. Kelsch, of Montreal, Quebec, said: We have in Montreal eight 1,000-kilowatt, three-phase, sixty-cycle generators, operated in multiple on a three-wire, three-phase system. We are using three-phase induction motors, and we have no more difficulty in balancing our three-phase system than is encountered in three-wire Edison system. We consider the three-phase motor has an advantage in its being operated from three transformers. In the event of one transformer failing the two remaining transformers can be readily connected up so that the service is reestablished in a very short time. We have no difficulty in our lighting work. Where we have large lighting installations of 2,000 to 5,000 lights, we divide this load up on the three-phase system by supplying three-phase, two-phase transformers. We are operating all classes of electrical apparatus, including rotary converters, induction motors, from one-half to 400-kilowatt capacity, synchronous motors of 150-kilowatt capacity. We consider that the three-phase has additional advantages aside from the saving of copper, consisting of reducing the number of wires required on the pole lines, which is an important item in a crowded city.

President Doherty: The idea in this discussion was to get some man to represent the three-phase side and another man to take the two-phase side. We asked Mr. Scott to take the two-phase side. He did not care to do that, but he wanted to tell the advantages of both. We asked him to lay stress on the two-phase side to see if we could not have a discussion. I think the way the discussion stands now none would go away with any clear idea whether we should use two-phase or three-phase, and none of us would have changed our mind at this juncture. If there is any one who has distinct views on the two-phase as against the three-phase, we would be glad to hear from him.

Mr. P. G. Gossler, Montreal, Canada: In regard to the two-phase distribution, we are supplying from generators running in parallel a system of 160,000 lights, and possibly 10,000 horse-power from the same distribution system. We are paying no attention whatever to dividing our business load between phases. We do not have to. We never give it any consideration whatever.

Mr. J. F. Dusman, York, Pa.: I would explain that we have an Edison three-wire plant where I am, and we are besides customers of the York Power Company. It is installing a three-phase system, I understand, and I am somewhat at a loss to know exactly how I can best apply its power to the installation. We have direct current and some alternating current, but not much of the latter. We are centrally located, and I would like to get some information, further than I have had, as to how we can apply its power to our plant and do it to the best advantage.

Mr. Welles E. Holmes, Newton, Mass.: We are operating a two-phase system as single-phase and we have no trouble. We do not pay any attention to the balancing up, and do not think we have to. We operate small single-phase induction motors on separate transformers on the lighting mains, and also operate four or five two-phase small motors of five horse-power on these mains. We can carry quite an unbalanced load, and it does not bother us at all on our lighting.

Mr. John F. Gilchrist, Chicago: I would like to have an answer to the question as to what can be said particularly against the two-phase system for isolated plants. In Chicago there have been several two-phase isolated plants put in. Naturally, even if we can not get the business at the start, we are anxious to see them put in three-phase plants, that being our system, so that we can later get hold of them without involving too much investment. If there is any argument we can use with isolated plants in favor of three-phase against two-phase, I should like to know it.

Mr. R. S. Kelsch: I wish to hear from any central station man who is operating the two-phase system, and does not pay any attention to balancing the load.

Mr. Behrend: Two-phase generators are no more independent than three-phase generators. Although electrically the phases are independent of one another they are connected magnetically through eddy currents and field currents, which produce voltage, and hence any change of load in one phase affects the other.

Mr. Paul M. Lincoln, Niagara Falls, N. Y.: We are operating at Niagara Falls the two-phase system and about forty per cent single-phase, and we find it necessary in that case to have our two phases pretty evenly balanced. If we do not we find that the induction motors, particularly which are on our system, heat up a good deal more than they would otherwise, because the tendency of any induction motor is to balance up between the two phases, and in cases of too large unbalancing the tendency for the motor to balance results in taking power from one phase and delivering it to the other at the expense of heating the motor. We find it necessary to balance the two phases pretty closely to avoid trouble.

Mr. Charles F. Scott, Pittsburg: One of the first statements made in the discussion is one which is of vital interest to this association in certain things that it involves. It referred to the four-wire three-phase system; 2,300 volts from the neutral to each wire, and 4,000 volts on the outside circuit. Do you realize that the board of underwriters has prepared and proposed a rule which would keep these 4,000-volt circuits seventy-five feet away from any building? I suppose this suggestion is sufficient, and that the committee on underwriters rules of this association will see what that means. The use of the 4,000 volts, as is implied in that rule, has come up from the point of higher voltages, and it is inevitable that the difficulties in the installation and the keeping up of a plant at 4,000 volts will be more than at 2,000 or 2,300 or 2,500 volts. The conclusions from that statement are that while a large and well operated plant, with good supervision and care, could run at 4,000 volts, it might be an injudicious thing to do it on smaller plants, where the care and attendance are naturally not so good and where the requirements for the higher voltages are not so great.

With regard to higher voltages, particularly in the case of transmission lines, a gentleman presented to me a few weeks ago a plan which he had for a transmission plant. He proposed to run at 30,000 volts and to run two circuits on the same pole line. I told him I thought he was getting high in voltage, and getting the circuits pretty close together; but that I would look over the estimate he had made covering all parts of the plant. I found the cost of copper in the transmission line was only about one per cent of the total cost of the plant, and that the cost of pole line, right of way and copper amounted to only two or three per cent. Now, considering water-wheels, generators, switchboards, transmission line, substations, considering the whole problem, the one point which would naturally be looked upon as the corner-stone, as the thing on which more care ought to be expended, is that high-voltage transmission line for thirty or forty miles through a desolate country. Yet he had that part down to about three per cent of the total cost. I explained to him that I thought his coefficient of reliability would be greatly enhanced by adding a few per cent to the cost of his transmission line, and when he revised his figures he had two pole lines instead of one, and at 20,000 volts instead of 30,000. In another case which came to my attention a short time ago, I happened to see the plan which had been adopted for the poles for carrying two 30,000-volt circuits. It was good, substantial construction, insulators on short pins, coming within an

inch or so of the cross-arms, the cross-arms provided with iron braces and the insulators with metal pins. It was an insulation construction for one or two thousand volts, but the man showed entire ignorance of the requirements of a 30,000-volt line. It happened that a gentleman from the West, who was operating a 30,000-volt plant, was in my office, and I showed him the blue-print, and he thought there would be a merry time there.

The three-phase transformer has been spoken of; that is, one transformer which would take three-phase current and deliver three-phase current. I have been trying to figure out for some time with Mr. Peck, our transformer designer, just wherein lies the advantage of a three-phase transformer over three single-phase transformers. There are some theoretical advantages, such as less material, but when it comes to practically building the transformers, the gain in efficiency, the gain in cost, is not much, and it is at a considerable sacrifice in building and at a considerable sacrifice in handling. Instead of having three units, one of which you can take away and use the other two temporarily, as has been suggested, you have all your eggs in one little basket, and I fail to see where the advantage comes in in a construction of that kind. I am also of the impression that the four-wire three-phase secondary distribution can not be very successfully conducted without the neutral wire from the generator also.

The gentlemen who spoke in regard to lighting on three-phase and two-phase systems almost all represented the larger stations. The gentleman who spoke for Montreal began with the statement that he had so many thousand kilowatt generators, and it is probable that he could distribute anywhere from such a large generating capacity. There would be little occasion for any great unbalancing and his regulation would be of a high order. It was mentioned, also, that the lighting in one of those cases was by three-phase two-phase transformers, and found to be successful. On thing is notable in this discussion of the central station men—they have considered lighting and the matter of balancing loads has not referred particularly to motor work. The lighting work has been a thing of the past; but the lighting and motor work, the combination, is to be the work of the future, and the more definitely you look forward to and plan for that work the greater will be the success of the future.

President Doherty: Before we go on with some of the questions relating to this subject, I want to appoint certain committees which should have been appointed sooner.

Committee on Memorials: Messrs. E. H. Davis, Williamsport; F. E. Smith, Somerville, Mass., and W. E. Moore, Augusta, Ga.

Committee on Nominations: Messrs. Frederic Nicholls, Toronto, Canada; James I. Ayer, Boston, and H. H. Fairbanks, Worcester, Mass.

Committee on Amendments to the Constitution, to be added to the former committee: Messrs. C. L. Edgar, Boston; G. E. Hay, Springfield, Ill., and Frederic Nicholls, Toronto, Canada.

We will now take up a few questions allied to the discussion which we have just had. The first is: "Can converters supplying street railway load be operated from three-phase or two-phase, sixty-cycle, separately excited alternators, which are at the same time supplying a lighting load of incandescent and arc lamps? Will the pulsating load on the rotary cause a fluctuation at the generator beyond that which is occasioned by engine regulation? Can this be done with perfect success without a storage battery auxiliary or some arrangement to take care of the wide fluctuations?"

We would like the members present to discuss this question.

Mr. J. H. Perkins, Youngstown, Ohio: Representing the Youngstown plant, I will say that we have all of the apparatus and all of the conditions outlined in this question including the storage batteries, and while we know what to do to get along successfully, I hardly know what to outline as a general case, and I do not believe it can be done. Each case must be worked out on its own merits. I heartily agree with what has been read as a written answer to this question, and lay more stress on the engine regulation, that is, the overload of the engine. It is a surprise to me, and no doubt is a surprise to others, that the rotary converters can be made to make up for all of the engine regulation or generator regulation. As we know, a railway load is fluctuating and it has great peaks, and if the engine is made large enough to take care of this the generator will be taken care of by the rotary, and I think a special operation can be obtained up to the point where the engine begins to lay down. The point of that is, as the written answer states, that the rotary be over-compounded and that it be set for a power-factor at a fifty per cent load. On lower load, the rotary will give the generator a lagging current which will tend to keep down the voltage, which would naturally rise on taking the load for both engine and generator. On loads greater than fifty per cent the rotary gives the generator a leading current which tends to raise the voltage and counterbalances for the drop in voltage.

As to whether all this service can be operated together, I do not think it can be done all the time. In any one plant we have changed conditions, and under certain conditions we can not operate in this way. During the daytime we are operating about 800 kilowatts in railway and 350 to 400 kilowatts in lighting and power. I do not believe we get any voltage variation of over two and one-half per cent, as shown in the written answer, and we operate perfectly satisfactorily. If the rotaries are properly designed with relation to the engine and the whole output, I do not think there will be any fluctuations due to the rotary transformer, and I take it from the question that the party means "pumping" effect.

In regard to the storage battery it does not have much to do with the more even regulation, except as it takes off the peaks which are too great for the engine. If the engine was considerably overloaded, the storage battery would save that part of it, but the regulation due to the rotary transformer is automatic and does not require any assistance from the storage battery. We have storage batteries where I can see no particular advantage in obtaining better regulation, except that it takes off the peaks which would be of advantage for the engine capacity. Our engines are rated very high as compared with the power of the generator. Generators on railway loads, especially alternating current, will stand great overloads; but if you have not the engine to do the work you can not get the regulation. [Applause.]

Mr. J. B. Foote: I can not discuss this subject from the standpoint of any one else; but I have been running such a plant for three years, and it may be of interest to you for me to give my experiences so you can draw your own conclusions. We have about 3,000 horse-power—water horse-power—a transmission fifty miles long, and during that fifty miles we take off current for railway, lighting and power, etc., distributing at 25,000 volts. We take all the lighting and railway and power work from one transmission line and one generator. The generator has an inherent regulation of five per cent, and our rotaries are compound. If we are using just the full strength on the rotaries we get a considerable lagging current. We can get lighting regulation of not over three per cent under any condition, even when they throw on interurban cars which weigh thirty tons. The operation of the plant has been satisfactory for three years. We do our lighting business single-phase. The commercial lighting is done from a 100-kilowatt transformer unit, with a three-wire secondary distribution and the pressure wire carried back to the plant and the regulator at the plant in the single-phase distribution circuit, so that we maintain the pressure on the secondary distribution.

President Doherty: We will now take up the following questions together. The first question is: "Is it Possible to Operate Induction Motors for Elevator Service and Other Intermittent Use from Lighting Feeders without Serious Disturbance to Electro-Motive Force?" The next question is: "What Specifications Should Prevail in Purchasing Induction Motors to Ensure Least Disturbance to Line Electro-Motive Force?"

We will consider these two questions together and would be glad to hear comments upon them.

Mr. Charles F. Scott: It appears to be the same answer again—it depends on conditions; sometimes you can and sometimes you can not. That is the true answer, just as the variety of answers which have been read indicates, that in some stations where the conditions are favorable various classes of motors can be operated without interference to the lighting service. In other cases it is not true. The same statement might be made with regard to direct-current motors. The ques-

tion might be put—Is it possible to operate direct-current motors for elevator service and lighting on the same circuit? I know of cases where the induction motor has been criticised for not doing good work on elevators where a direct-current motor would not be used, and in such cases the induction motor is expected to do more than the direct-current motor would do.

With regard to the specifications for purchasing induction motors, specifications are sometimes presented which place the starting current as a certain fraction of the full-load current, independent of the size of the motor. That is evidently not a fair thing, as a circuit which will enable a ten-horse-power motor to start with, say, its normal full-load conditions —that is, taking its normal full-load current at the start—would permit of a one-horse-power or two-horse-power motor being started with two, three or four times its full-load current, and not make the same disturbance on the circuit that the ten-horse-power motor would starting with only its normal current. It would be better, therefore, in specifications of this kind to place some limit upon the amount of current which can be taken from the circuit, or make different specifications for different sizes of motors, instead of making a specification which refers alike to all motors. If the starting current is specified in terms of a full-load current, then it may be that a poor motor would pass the specifications and a good motor would not. For example, suppose two motors were used which took the same starting current, but one of them took a considerably greater running current than the other, the one with the greater running current would be the poorer motor, but as it takes less starting current it might pass the specifications where the other motor would not.

The answers to the questions which are now proposed should come preferably from those operating stations, giving their experiences and the conditions under which they get favorable or unfavorable results. The discussion of questions of this kind from the men who are doing the work is particularly valuable in a case of this kind.

President Doherty: The next question is, "What has been the experience from use of single-phase induction motors above one horse-power on lighting feeders?"

Mr. Arthur Williams, New York: I do not know that this question can be answered under that head, but I would like to know if any one can say why there should be a material difference in the cost between single-phase motors and two-phase or three-phase motors? Why should not the cost of a single-phase motor be more proportional to the cost of the other type.

Mr. Behrend: Any multiphase motor gives its output with less material than the single-phase motor. You may consider a single-phase motor as a two-phase motor, one phase of which is cut out or interrupted.

Mr. Williams: I understand that the answer is simply that there is more material required per horse-power in the single-phase motor and the cost is more for that motor on that account?

Mr. Behrend: There is a difference between cost and price. You have to compare shop cost and selling price on two entirely different bases. You may have to sell a three-phase motor for about two-thirds of what you would have to sell a single-phase motor.

Mr. Frank H. Taylor, Pittsburg, Pa.: I think that is a commercial question altogether, and I do not understand that we are here to discuss commercial questions from that standpoint. As I understand it, however, the experience of central station people with alternating-current motors is about the experience that I used to have as a salesman for the Yale locks. There was no apparent reason why Yale locks should cost more than the locks of any good manufacturer; but any one who bought a Yale lock was never sorry he bought it and paid the price which it cost. The same thing is true of induction motors. The price is not excessive, and any one who buys one motor buys more.

President Doherty: We will now take up the next question, "What method of protection should be used when transformers are operated with interconnected secondaries to prevent a short-circuit at one point from blowing the fuses on all transformers feeding the connected network?"

Mr. Leonard Andrews, Hastings, England: This is a question in which I have taken considerable interest. In our system in Hastings, England, we have our low-tension network connected together, and it is fed by transformer substations at various points in the town. We have found it is useless to attempt to put fuses in any position in the low-tension network, as a failing transformer invariably short-circuits the network without blowing the fuse between that and the network, blows a number of fuses in other places, and often cuts off the supply to the whole district.

We use between the secondaries of our transformers and the low-tension network return-current cutouts, that is to say, cutouts which only operate when a transformer ceases to supply energy to the network, and receives energy from the network. We have all of our transformers equipped in this manner, and we have not the slighest hesitation in short-circuiting either the primary or secondary winding of the transformer connected to the network at any time, as the automatic return-current cutout referred to can invariably be relied upon to cut out the faulty apparatus.

President Doherty: We will now take up the report of the committee on standard rules for electrical construction and operation, of which Captain William Brophy, of Boston, is chairman.

Captain Brophy: The only question of importance to this association, so far as standard rules go, which has developed during the past year, is the proposed amendment to the rules which will practically exclude from the streets of every city and town all alternating currents having a difference of potential above 3,500 volts. If that rule is enforced, the four-wire system described here can not be used and the wires will not be permitted to come within seventy-five feet of the building. It requires for all high-tension alternating circuits a private right of way, or else they must go underground. I have endeavored to meet the question by showing the inconsistency of the thing. We have to-day series arc circuits, with a difference of potential at the bars of over 8,000 volts. If 3,500 volts alternating are dangerous certainly the 8,000 volts series arc circuits are dangerous.

Your committee desires instructions as to what course it will pursue in meeting this proposed amendment.

The next method which we should suggest would be to question the right of any organization doing a commercial business, which the board of underwriters is doing, to hamper the business of any other class of people who is doing a legitimate business. In the first place, the underwriters have no control over the wires in the streets or under the streets, except as they may affect the matter by increasing the insurance rates generally. They have no legal right to do it, and perhaps it will be necessary to meet that. Whether they can destroy the business of the people engaged in the electric light business is a serious question. Unfortunately, one of the troubles with the underwriters' association, in relation to the rules, is that it has very little conception of the amount of damage that can be done by rendering obsolete standard articles that cost thousands of dollars and which are now in the hands of people doing a lighting and power business. It evidently does not stop to think of that, but that is a matter of the greatest importance to those business people who would be affected by any arbitrary rule of this character which it might make.

President Doherty: Captain Brophy desires suggestions as to how his committee should proceed to overcome the adoption of this rule proposed by the board of underwriters.

Mr. W. L. Abbott, Chicago: I do not think it is possible to enforce this rule, and I do not think it expects to. To show how absurd it would be to attempt its enforcement I will say that we have in the city of Chicago over fifty lines of pole lines carrying 4,000 volts and over. Any building that is approached within seventy-five feet by these lines would be subject to this rise in the rate of insurance, and any other line which it comes in proximity to will affect the buildings along its course in the same way. We are crossing telephone wires, telegraph wires, fire-alarm wires, and other wires in all directions, and these wires are ramified all over the city, so that practically, to enforce this rule, it would have to raise the rate on the entire city of Chicago.

Captain Brophy: I feel, as chairman of the committee, that it is desirable to separate low-tension wires, such as telegraph, telephone and signal wires, as widely as possible from high-tension wires. We all agree in that. My opinion is if the wires

are kept separated from all other wires and, where they do cross, are so constructed that it will be difficult to have them come in contact, that it is not necessary to enforce this rule. I shall, of course, do all I can to show the board of underwriters the unwisdom of passing this rule. It is now in the hands of a committee to report upon. What its report will be I do not know. I believe the original committee practically acceeded to the passage of this rule, but the committee has been added to, and I think that men of larger experience in such matters have been added to that committee, and I hope the final result will be different from what was at first accepted.

President Doherty: I think that is the sentiment of this convention, that the committee should use its best endeavors to convince the underwriters that it is not good policy to enforce this rule.

At a subsequent session of the convention the following resolution was passed:

"*Resolved,* That the amendment to the National Electrical Code proposed by members of the Underwriters' National Electrical Association, and now being considered by the American Institute of Electrical Engineers, limiting the difference of potential in all overhead alternating circuits to 3,500 volts, is uncalled for and should not be adopted. Good and safe construction, rather than elimination of voltage, is what should be insisted upon for all overhead electric lines."

The convention then took up the consideration of topical questions, after which it adjourned.

WEDNESDAY AFTERNOON, MAY 21.

President Doherty called the meeting to order at 2.10 P. M.

The convention then continued the consideration of topical questions. Among the questions considered was the following: "What advantage has the series system of enclosed arc lighting for street circuits over the multiple system, other than the saving of wire in making the circuit and the doing away of independent transformers on the line?"

Mr. L. B. Marks, New York: I think that $10 a year is about the average saving that central station men report. Of course, I have to be guided by what they report in that respect. I have taken the statistics from a large number of central stations, and the average saving per lamp per year in street service is approximately $10 per lamp per year.

President Doherty: What do you say the cost is for trimming open arc lamps?

Mr. Marks: That depends upon conditions and upon how many arc lamps a trimmer can take care of. In some cities the number of lamps a trimmer will take care of, we will say, will be 100 lamps, and that, at $2.50 a day, will average two and one-half cents a lamp, but in other cities the figures vary considerably from that. The same thing is true with the enclosed arc lamps. Take the average trimming of enclosed arc lamps in some cities and the trimmers will trim seventy-five a day, making the cost of trimming per lamp fifty per cent more than the open arc lamp; but, taking all the figures together and averaging them up, I think the figure I stated is fair, and I believe I am borne out in that determination by others who have made the same investigation; and that the saving is approximately, in round figures, $10.

President Doherty: I am trying to get the gross amount by which you get the difference. You subtract one amount from the other, which leaves $10. What is the gross amount?

Mr. Marks: I think the average figures would be six and sixteen, along in there, giving a difference of ten.

Mr. P. A. Bertrand, Peoria, Ill.: Our cost for 600 street lamps averages between ninety cents and one dollar per lamp per month with the open arc. That does not include the night inspector, whose salary would raise that about ten cents per lamp, making the average cost about $1.05 per lamp per month. We have a very small number of alternating series enclosed lamps, and these are costing us about fifty cents each per month. With a greater number of alternating lamps, I have no doubt we could materially reduce the cost of maintaining the enclosed alternating arcs, but these figures give the cost of the enclosed lamp, which in this case is alternating, as compared with the open arc, about one-half, and make the cost per lamp per year, that is the open arc, about $11, and with the enclosed lamp between $1.05 and $6. In regard to our trimming, each trimmer takes care in the neighborhood of 100 lamps, some slightly more, some slightly less, but they take care of them in a satisfactory manner and get through with their work in short hours of labor.

Mr. Fred C. Smith, Aurora, Ind.: I think the gentlemen do not take into consideration the systems in the different towns. The tendency of the day is to light up the country districts which cause the trimmer to retrace his steps. Our alternating lamps are in position which is more favorable to their being trimmed than the average alternating lamps, and I should judge, to make a rough figure, that our cost is nearer $12 than $10.

Mr. A. H. Mainwaring, Philadelphia: In Philadelphia we pay our trimmers on the piecework system. We pay two cents per lamp for trimming, and the average trimmer takes care of about 100 to 125 lamps. Where we gain on our piecework system is on Sunday. While we used to pay $2 per day for trimming, including Sundays, now some of the trimmers have only about twenty lamps to trim on Sundays, and in that way we consider that we are saving money by paying for work on the piecework basis.

Professor C. P. Matthews then read the "Third Progress Report of the Committee for Investigating the Photometric Value of Arc Lamps."

Professor Matthews said also: I want to add, Mr. President, that this probably closes my connection with the arc light committee work, and inasmuch as certain parts of the work have been criticised for one cause or another, I want to say that the aim I have had in view all the time has been to get at the truth. I think those who have been disappointed in our work have been disappointed because the values were not shown to be larger. That is a remnant of the old thousand-candle-power idea. I feel confident that the results are more accurate than any other arc light investigation that has been undertaken, in this country at least. [Applause.]

President Doherty: I was appointed chairman of the arc light committee, but during the last year and a half the work has devolved entirely upon Professor Matthews and Professor Goldsborough. I feel that they have done excellent work for the association and something of immense value to the entire electrical fraternity. I do not think the work should be stopped here, but it should be carried on. I think that the committee has reached the point now where valuable deductions and conclusions can be made. The one point brought out in this report has been verified by the support this association has given this committee in its efforts to fix the proper unit for any certain arc lamp. I have not had a chance to confer with Professor Matthews since he came to the convention, and am sorry to hear him say that this report closes his connection with the arc lamp work. If it closes his connection with the work it probably means that the work will be stopped, or at least it means that the other two members of the committee are not now so situated that they can do any work along these lines. They could take these old reports and make some valuable deductions from them, but for them to undertake further research and experimental work would be impossible, I am sure.

There has always been more or less criticism of the work of this arc lamp committee; in other words, I am sorry to say many of our members were not looking for the truth in arc lamp photometry, but looking for inflated values. I do not think there is any reason why we should try to give the arc lamp a greater value than it possesses, as we are competing with a more profitable branch of our business, the incandescent lighting. We want to know the true value between the incandescent and the arc light. There is not a central station represented in this association, no matter how active the competition may be from other sources of illumination, but could do twice as much business in every town as it is doing to-day. I firmly believe that, although it is a pretty strong statement. I dare say there is not a member represented here who has an income to exceed $3 per capita for lighting alone, with the exception of New York city, but we know from statistics, that some stations have gone over $6 per capita for lighting. I dislike to see this work abandoned. There is much further work, especially the relationship between incandescent and arc lights, which I hope to see brought out in future reports. There is also work I desire to see brought out regarding the relationship between oxide filament lamps and arc lamps. The mat-

ter is entirely in the hands of this convention whether it wishes to continue this work, attempt to continue it, and whether we can prevail upon Professor Matthews to keep the work up. The criticisms have been hard to answer, but they all point in the aggregate to the fact that the arc lamp was losing the value which it was supposed to possess before this investigation started.

I am just making a very careful determination of how best to light the streets of a certain city. With the same expenditure of money I can give them a minimum illumination of nearly ten times as much with parallel connected incandescent lamps that I can with open arc lamps. We have tried to carry out the suggestions we have received from members from time to time, but some of the suggestions that have been offered have been impossible more than impracticable, at the stage we had to start in to work. There were no values determined which we could accept and up to date the work has been carried on very unsatisfactorily, largely in the nature of research and not in the nature of practical work. The thing is in shape now to make real and practical use of a résumé of the reports and deductions gained by the experimental work done by Professor Matthews and his assistants. I desire to call these matters to your attention and the subject is now open for discussion.

Mr. L. B. Marks, New York: The report read by Professor Matthews fairly bristles with facts of special interest to central station men.

To my mind, one of the most interesting sections of the report is that relating to tests of a 450-watt arc under varying conditions. These tests show the relative light-giving values of practically all the types of open and enclosed arc lamps. The results prove quite conclusively the superiority of opalescent inner globes over clear inner globes for street lighting. This superiority is due to the better distribution of light given by a diffusing globe. An objection which has often been raised against the enclosed arc lamp is that the light given out is cut down by the absorption incident to the use of double globes. While this is true, generally speaking, Professor Matthews calls attention to the case of an alternating-current enclosed arc lamp in which the amount of light given out below the horizontal is actually greater with two globes on the lamp than with one. In the case in point, the outer globe (clear glass) acts like a reflector, thus increasing the mean hemispherical candle-power over that obtained with the single globe.

Another point to which attention is called is the superior distribution of light obtained by lamps equipped with "continuous" or closed-base inner globes. The contour of the globe undoubtedly accounts for this.

It is interesting to know also that the mean hemispherical candle-power of the 6.6-ampere alternating-current and enclosed arc lamp fitted with a suitable reflector is almost as large as that of the 6.6-ampere direct-current arc. This bodes well for the extended introduction of alternating-current series enclosed arcs.

The concluding chapter of the paper treats of the relation between distribution of light and the height of the lamp above the street level. Professor Matthews finds that the greatest mean illumination obtained from the open arc tested is produced when the lamp is about forty feet above the ground, as contrasted with from twenty-five to thirty feet for the enclosed arc. If the mean illumination were the only thing to be considered these figures might serve as useful standards. But in commercial practice, especially with reference to the open arc, the most desirable height of the lamp above the ground will be largely influenced.

Professor W. E. Goldsborough: I am commissioned by the president and board of directors of the Louisiana Purchase Exposition Company, in connection with the World's Fair to be held in St. Louis, Mo., in 1904, to extend to the National Electric Light Association a hearty and cordial invitation to hold its twenty-seventh convention on the exposition grounds. The exposition authorities also ask your cooperation, if you are willing to extend it to them, in the development of a thoroughly representative electrical display which will do much to show the numerous and varied applications of electricity to the industries, and help in building up the further application of electricity to the industries. The Electricity Building will be a large structure, 600 feet either way, and will equal the area of four city blocks. The Exposition company has not been mean in setting apart a substantial space for exploiting electricity.

I am more or less convinced, and the idea seems to be quite prevalent, that electricity has reached the point where it can be recognized as one of the forms of energy upon which we are dependent, and we naturally expect that if future expositions are held electricity will hardly be accorded a special place. It will be catalogued as other forms of energy, the same as gas, air, water, etc. We have, then, an opportunity now to show the world the final outcome of the energy and skill that has been expended in developing electricity. I hope with the cooperation of the electrical fraternity that it will be possible for us to do something that is commensurate with our ideals of what electricity means to the world. [Applause.]

A resolution as follows was unanimously carried:

"Resolved, That the annual meeting of this association in 1904 be held on the grounds of the Louisiana Purchase Exposition Company, at St. Louis, Mo., and that the association will lend its best endeavors to contribute to the achievement of such an electrical exhibition as the considerations of the exposition management (as indicated by its generous provisions) and the industry demand."

Dr. F. A. C. Perrine then read his paper entitled "Protection of Long-Distance Transmission Lines."

It is assumed that the subject of protection of long-distance transmission lines is intended to cover only the question of protection of these lines against lightning and other static discharges, since any other interpretation of the word protection might involve every question concerned in the design and construction of such a transmission line. Essentially the protection of a long-distance transmission line is the same as the protection of a shorter, lower potential line, though by this I do not at all mean to convey the impression that the protection of high-potential long-distance lines is no more difficult than the protection of other lines, since, as all know who have attempted the problem, there are many new difficulties arising in this problem and many difficulties of inconsiderable amount in lower potential work which rise to great proportions in all long-distance transmission work. The reasons that there are greater difficulties in protecting transmission lines are:

First, on account of the extent and character of the territory traversed. In the summer time lightning storms of small area are matters of frequent occurrence and the problem is sufficiently difficult where one has to encounter only the storms that occur in any one section of territory, but where lines extend over distances from twenty to fifty, or even up to one hundred miles, it can readily be seen that the multiplication of the chances of interference from disturbances of atmospheric potential is very important and that such a line must be protected efficiently at all times, irrespective of the particular character of the weather at the station, and, in consequence, those interesting means of lightning protection which are connected to the line only when danger is apprehended can not, in such cases, be contemplated. Furthermore, transmission lines pass through country varying materially in elevation and in certain conditions of the atmosphere there are produced disturbances along the line entirely apart from the existence of any lightning storms. Scientists have found by flying kites that at times a few hundred feet difference in elevation gives variations in air potential amounting to several thousand volts and the probability of a line which extends over a broad stretch of country and surmounts noticeable elevations encountering such variations of air potential is very great and must be guarded against. This one reason for the increased difficulty of the long-distance transmission problem is, in itself, sufficiently convincing, but we must also remember that the laws of high-potential strain and high-potential arcs are not very thoroughly understood. Calculations based on 2,000-volt protection are altogether unsatisfactory when the potential is increased to 5,000 or 10,000 volts, and doubling the voltage again brings in a new set of phenomena, whereas the final increase of potential up to 50,000 or 60,000 volts seems to throw to the winds all previously ascertained rules and regulations for procedure in lightning protection. All apparatus producing open-air arcs must be carefully avoided where the lines are long and the capacities and self-inductions great. Open-air arcs being of rapidly oscillating character actually raise the potential along such lines and introduce of themselves difficulties similar to those produced by lightning discharges. Before going into any question of the actual means used for protection of long-distance lines, we need first to recall to mind the fact that in protection of any line we are protecting—First, against the induced surging currents on the line produced by neighboring lightning discharges. Any lightning discharge in the neighborhood of a transmission line induces a high-potential current on the line which must be safely gotten rid of. Secondly, we must provide against the occasional striking of the line of a small side flash. Finally, we must do what we can to protect against a direct lightning flash, though generally this is necessarily destructive where it hits.

General atmospheric differences of potential and small induced charges can be best taken care of by a frequently grounded wire

run in the neighborhood of the line. Some reports have been received of a loss of energy presumed to be due to the presence of this grounded barbed wire, but careful measurements that have been made on lines loaded and unloaded, in order to find out the exact effect of this barbed wire as an absorber of energy, prove pretty conclusively that its presence does not produce any material loss of energy. Choke coils, which are commonly used as a part of lightning arrester outfit, undoubtedly sometimes have beneficial effects if there is a separate path to earth through a set of arresters for every choke coil, but there seems to be no doubt but that their effect is present at certain rates of oscillation and not at others; consequently they can not be considered as a sure means of aiding the lightning protection. If a high-potential line is efficiently protected by the ordinary form of gap arrester, there sometimes is present on the line potential not sufficient to pass through the gaps of the arrester and, at the same time, sufficient to pierce the insulation of the machinery. This high-potential charge can be gotten rid of through small gap-line discharges backed up by means for preventing the dynamo current from following the lightning discharge. One of the most efficient pieces of apparatus of this kind being in nature similar to the Branly coherer which permits the passage of small currents of high periodicity and high voltage but effectually prevents the passage of currents of low frequency and potential. It hardly seems necessary in any particular way to call attention to the various standard lightning arrester types since these are sufficiently familiar to all, but only to warn against the error of attempting to provide gap arresters with enough gaps for protecting high-potential circuits and preventing dynamo from following, since when the potential rises above about 30,000 volts, this type of arrester is no longer available and in series with a moderate number of gaps must be inserted either a resistance or a condenser, the probability being that the use of a condenser will be found to be the preferable plan. Finally, I would state that with the use of a barbed wire, lightning arresters and line discharges we have done the best possible in the protection of any long-distance lines, but, at the same time, feel constrained to confess that the engineers have still much to do before they can say that they have offered such perfect protection to long-distance lines that there will be no further trouble from this source.

Mr. P. M. Lincoln: We had a barbed wire on the Niagara Falls line in the early days, but on account of the severe wind and sleet storms it was practically of no benefit in the winter time and we took it down, and since that time, four years ago, we have had no barbed wire protection, although I believe that the barbed-wire protection would be a good thing, and it will probably be put up again in better shape in the near future.

Mr. Cushman: I had a very good illustration of the barbed-wire protection in 1887. We had a small plant in one of the Texas cities, and they strung the barbed wire up over the line for grounding lightning bolts, and in the station we had nothing but the old style lightning arrester, with fuses and cap, the regular saw-tooth style. There was not a storm within 300 or 400 miles of us when we did not have the apparatus afire and the fuses burned out. I got out and took the barbed wire down and the trouble materially disappeared.

Mr. Lincoln: I ask Professor Perrine whether protection due to the barbed wire or a wire for protection purposes strung on the poles would not be increased by decreasing the resistance of the wire? Would not a low-resistance copper wire be better than a higher resistance wire for that purpose?

President Doherty: That is the question which about 100 members asked us to discuss. Evidently they are all absent.

Mr. F. C. Scott: As to the lightning arrester, one of the functions of the arrester, its ability for protecting circuits and other apparatus, has been fairly satisfactory, but going up to these very high voltages, as Dr. Perrine has pointed out, bring in new conditions which it is impossible for the designers to meet without getting the practical conditions of the operating circuits. That is a matter which Mr. Wurts gave some attention to a few years ago, and Mr. Thomas, of the Westinghouse company, who has recently presented a paper before the American Institute of Electrical Engineers, expects to go out and visit some of these plants this summer and make investigations on the ground. It is a most excellent thing to bring up a subject of this kind before the practical men in the business in order that they may keep in touch with the designers of lightning arresters and help them in making apparatus which will meet the practical conditions. The fact that these lines have been operating and operating well, going into these very high voltages, within the last few years, seems to me to speak well for what we may hope to have in the course of a few years, as the conditions are better known and the apparatus can still be further perfected. The arrangement which Mr. Lincoln spoke of, namely, a combination of serious and shunt resistance, is one which was the result of a considerable amount of experimental work at Niagara Falls, on the machines which are installed there, to determine the proper proportions for interrupting discharges (artificial in that case) across the arrester gap, and that which Mr. Lincoln has pointed out as being the most satisfactory arrangement on his circuits, is the one which Mr. Nunn and Mr. Thomas are trying in conjunction on the high-voltage circuit which Mr. Nunn has out on his lines. Mr. Nunn can be considered as one of the pioneers of this high-voltage work, having operated a 40,000-volt line, I believe, a considerable time in advance of others and his testimony on this subject is very excellent and valuable.

Dr. F. A. C. Perrine, Pittsfield, Mass.: I suggest to Mr. Lincoln if he finds that the barbed wire will not stand up under the strain of sleet storms that he have it made of plough steel and it will stand as well as copper. The barbs are undoubtedly effective in protecting the line.

The meeting then adjourned to visit the works of the Bullock Electric Manufacturing Company at Cincinnati.

WEDNESDAY EVENING, MAY 21.

President Doherty called the meeting to order at 7.50 o'clock, in executive session.

In the executive session the officers for the ensuing year were elected, whose names have been given previously.

President-elect Ferguson was escorted to the chair. He said: Mr. President and gentlemen, I thank you most heartily for the honor you have conferred upon me in electing me to the presidency of your association, and I am especially gratified at the unanimous manner in which you have elected me. I shall endeavor, with your assistance, to administer the duties of the office to your entire satisfaction.

President Doherty: I congratulate you, Mr. Ferguson. Gentlemen, I think we will all find that the affairs of the association will thrive and prosper under Mr. Ferguson's management.

Mr. Frederic Nicholls, of Toronto, Canada, proposed a vote of thanks to retiring president Doherty, making a very felicitous and complimentary speech in so doing. The motion was unanimously carried by a rising vote.

President Doherty said in reply: If I have worked hard for the success of this meeting, I certainly have been well repaid for it by the thanks you have given me and the appreciation you have shown for my labors. I do want to say, as I said in my presidential address, that Miss Billings, the assistant secretary, I think, deserves more credit for this meeting than any other one person. I want to share in the credit if the meeting is a success, but Miss Billings deserves more credit than any one else. [Applause.]

Mr. Russell Spaulding then read a paper on "Display Lighting, Signs and Decorations," of which a brief abstract follows:

The fact that a large number of units of light is infinitely better for decorative purposes than large and intense light centres has long been known. Before the advent of electricity in a commercial form the chief illuminant was gas, and this in turn was preceded by the candle. For decorative purposes the first notable use of ten and eight-candle-power lamps on a large scale was at the World's Fair in Chicago, and the eight-candle-power lamp proved its desirability by the further success attained in the lighting of the Pan-American Exposition. To-day the four-candle-power lamp is the standard for much decorative work, one, two and three-candle-power lamps being also largely used.

A few general rules might be formulated as follows: The nearer the distance to the observer, the smaller the unit should be in size and intensity and the nearer the units should be to one another. Displays at short range, such as indoor decorations, should invariably consist of frosted lamps, and the distance between lamps should be such that the halation is of practical and uniform value from bulb to bulb, especially when continuity of line or curve is essential.

In electric displays, as in everything else, success depends on harmony; the creation of an harmonious whole is a problem even where only white lights are used. Where color is introduced it becomes more complex. A mistake is often made in introducing too many different colors in decorations. Single tone effects, or effects involving white lights alternating with some one color are the most satisfactory. White frosted and green frosted bulbs in alternation are probably the most desirable and peculiarly fitting for all forms of decoration.

The aim and object of all display lighting, either in decorations or signs, is to make an attractive effect. This is best attained by avoiding glare and obtrusiveness.

The chief obstacles to decorative lighting have been great cost, defacing of rooms in installation of temporary decorations, lack of safety apparatus, lack of small lamps that

can be used in multiple on 100-volt and 110-volt circuits, length of time necessary to prepare for decorations, and the length of time consumed in erecting them.

Leaving attractiveness out of consideration, a consumer might be deferred from erecting an electrical sign comprising 100 sixteen-candle-power lamps owing to the large cost of maintenance, while the cost of maintaining 100 eight-candle-power lamps might also deter him, whereas the maintaining of 400 four-candle-power lamps might also seem reasonable. Where the incandescent bulb is used simply to dispel darkness and to permit the pursuit of business when daylight fails, the consumer will most likely try to get the most for the least money, and will exercise economy that the central station might deplore. If, however, he has a method of lighting that is not only going to dispel darkness from his premises, but has the additional feature of being pleasing to the eye, and will enchance the beauty of the store or residence; in short, give him a method which is attractive, he will probably use more current than he ever did before. He will not only use it in his electroliers but in making window displays attractive, for illuminating advertising cards and for electric signs if they are going to cause comment and draw trade to his place of business. On occasion that he wishes to make festive, he will replace the bunting and floral decorations with electrical festoons and garlands and emblems. To-day the markets afford means of making all these decorations, and it is to the central station manager's best interest to encourage their use.

A paper on "Possibilities of Sign and Decorative Lighting," was then read by Mr. E. J. McAllister.

The meeting then adjourned.

THURSDAY MORNING, MAY 22.

President Doherty called the meeting to order at 10.15 o'clock.

Topical questions were considered, among them the following: "What results have been obtained from the use of Nernst lamps?"

Mr. S. T. Dunham, Hartford, Ct.: We have had these lamps in use for fifteen months. The use we have made of the lamp has been principally experimental, to determine its value. Of course, not having any price for either glowers or lamps it was not possible to determine the comparative economy of the lamp. But we have come to this conclusion—that the Nernst lamp is closely related to the arc lamp in the matter of trimming. Every arc lamp is a new lamp every time you trim it; every Nernst lamp is a new lamp every time you trim it. You have that advantage in a Nernst lamp, as related to the arc lamp. It requires also about the same care in repairing and cleaning, principally cleaning. I expect to install this coming year about 5,000 of the Nernst lamps, which shows that we have confidence in them. I have no doubt whatever (although it is a lamp of luxury, as the Edison was in our collection) that the Nernst lamp will come within our reach as a bread and butter lamp more rapidly than the Edison, because it has severer competition. It must be put in such shape that it can be manufactured on a large scale, but you can not reduce prices till you do manufacture on a large scale. I think the lamp is certain to be a success.

Mr. A. J. Wurts, Pittsburg: I want first to call your attention to the life of the glower. So far one of the chief causes of the early breakage in the glower has been the mechanical strain on the glower. Unfortunately, those who use the lamps have not the information we would like them to have, and they are not aware of the fact that the glower expands and contracts particularly at times of lighting and turning off. The glower should be perfectly free and have an end play of about one-sixteenth of an inch. If it has that end play no mechanical strain will be brought on the glower, and the average life, barring a defective glower or accident, should be 800 hours on sixty cycles. Right in line with that remark I will answer the question with reference to frequency. The life of the glower is 800 hours on sixty cycles, and 400 hours, apparently, on twenty-five cycles. We have not full information on the latter point. There are experiments being carried on in Buffalo on the circuit from Niagara Falls, which indicate a considerable longer life than 400 hours, but these experiments have not been completed, and I can not say anything definite at this time. The figure of 400 hours that I am giving you is based on results obtained from about 350 six-glower lamps, which are operated in the factory of the Westinghouse company on twenty-five cycles. On the 16,000 alternations, the life seems to be about 1,200 hours. The experiments on that number of cycles have not been exhaustive, but the indications are that the life is about 1,200 hours.

As to the cost of trimming, we have not any complete data on that. I think we must look to the central station men for that information, largely. The Westinghouse Machine Company has a large number of six-glower lamps in the factory and it has kept a record of the labor required to take care of the lamps, and its figures indicate that it requires a one-man hour for 800 lamp-hours on the six-glower lamp. I have not verified these figures, and do not know anything about them, personally. That is taken from its records.

As to the prospects for a direct-current lamp, you probably all know that our European friends have labored along the lines of a direct-current lamp, exclusively. They have not made the alternating-current lamp, as far as I am aware, so that the direct-current lamp is not only a possibility, but a fact. We think we are doing wisely to work along the lines of the alternating-current lamp rather than to parallel their work. As a result, we have found that the life of the glower on the alternating current is much greater than with direct current, and we have continued along the line of alternating-current work with the idea of putting our best foot forward first. But we are now making direct-current glowers, and we propose to put them on the market very shortly. Probably by September 1 we shall be in position to supply direct-current lamps in quantity. One other interesting feature in connection with this subject is that all lamps will be exactly the same, whether for direct current or alternating current; that is, by the lamps, I mean that everything in the lamp, except the glower. The direct-current glower will be different from the alternating-current glower, and the same remark applies to using lamps for different voltages. As an illustration, take the six-glower lamp, for 220 volts, that is adjusted for 200, 230, 240 or whatever it is, and the lamps are the same in every respect except the glower.

As to the position which the lamp must occupy, so far we have only made lamps which will operate in a downward, vertical position. The reason for that is the cut-out, which operates by gravity. For any special cases we could reverse the position of the cutout in the lamp, and in that case the lamp would operate in an upward vertical position; but we have felt that the light should be thrown downward instead of upward and have taken no steps to make a lamp which will operate in any other position than the downward. We have endeavored to make what we call a "universal lamp," that is, a lamp which will operate in any position, but that will require something in the nature of a spring for a cutout, and a spring is not always reliable, we have found.

What is the useful life of the glower? Possibly that is a good deal a matter of opinion. The total life of the glower seems to be, as I have stated, about 800 hours on sixty cycles. Whether that would be considered the useful life or not, must be determined by you. Nevertheless, even at the end of 800 hours the glower still has an efficiency which will compete with other lamps now in use.

The efficiency question is a difficult one to answer satisfactorily. It seems to me, and I think most of you will agree with me, that the efficiency of the lamp should be based on its earning capacity. That is the efficiency of the lamp. But many of you will want, I know, the efficiency of the lamp as given by the photometer bar. We have, of course, made many measurements on the photometer bar and these measurements have been of value to us in guiding us in our work, but we have not found any customer yet who cared anything about the measurements made on the photometer bar. The dry-goods man, the hotel man or the office building man, does not care anything about these measurements. If he can see the light and see the general distribution and quality of the light, and how it compares with other lamps he is familiar with, he makes up his mind whether he wants the lamp or not.

President Doherty: We will now have the report of the Committee on Standard Candle-Power of Incandescent Lamps.

Upon motion of Mr. Ferguson the report was accepted.

Mr. Frank A. Wolff, Jr., representing the Bureau of National Standards at Washington, D. C., then addressed the meeting describing the present work and future plans of the bureau.

The question: "What is the best practice regarding the transposition of high-potential alternating-current lines, one to fifteen miles in length?" was then considered.

Mr. P. A. Bertrand, Peoria, Ill.: Not a very long time ago—last summer—we changed from 1,000 to 2,000 volts. While

that is not a very high tension compared to the system which Mr. Lincoln represents, it brings out the point. We divided our current, the primaries, by two right through. The effect on the city telephone lines and police alarm lines was not to decrease the induction on their lines, but rather to increase it, which would point to the fact that it is static rather than dynamic effects which cause the trouble.

A paper, "Performance of Present 220-Volt Lamps," was read by Mr. Fred W. C. Bailey.

Mr. F. W. Willcox, Harrison, N. J., opened the discussion.

The convention then proceeded to consider the question of rates. The papers on the subject were read and they were followed by a lengthy discussion.

The discussion on rates had not been completed at the hour of adjournment on Thursday morning.

THURSDAY AFTERNOON, MAY 22.

President Doherty called the meeting to order at 2.20 P. M. Topical discussions were considered. There was no report presented from the Committee on Flue Gases, but it is understood that the report will be filed and printed in the proceedings of the convention.

A paper by Mr. Hodgkinson on "Steam Turbines" was then read, and a brief abstract follows:

The conditions of operation that are most desirable for turbine work are: First, a fairly high boiler pressure; second, a good vacuum, because the turbine is capable of utilizing the expansive energy of the steam down to the utmost limits of exhaust pressure. Between 26″ and 27″ of vacuum generally means a saving of six per cent in steam consumption in favor of the higher vacuum. Third, the use of superheated steam. There are no rubbing surfaces inside the turbine where the parts are in contact with the steam, so there are none of the objectionable features that are sometimes incidental to the operation of reciprocating engines with superheat.

The essential working parts of a turbine consist of little more than a shaft revolving in two bearings. These are amply flooded with oil, and the bearing pressures are low and we do not believe that the journal actually comes in metallic contact with the bearings at any time. At all events, turbines that have been in operation many years have shown no wear whatsoever in the bearings. In fact, the tool marks have not even been rubbed off.

Mr. W. L. Abbott, Chicago, Ill., opened the discussion which was participated in by Messrs. Cahoon, Abbott, Junkerfield, Hodgkinson and others.

The convention then took up the further discussion of the question of rates.

The Committee on Resolutions, consisting of Messrs. Field, of Columbus, Ohio; Conover, of Pittsburg, and Davis, of Williamsport, Pa., then presented a report.

The resolution of thanks was unanimously adopted.

The Committee on Memorials presented a fitting report with respect to the members of the association who had died during the year:

C. C. Howell, vice-president and general manager of the Knoxville Traction Company and the Knoxville Electric Light and Power Company, Knoxville, Tenn.; Frederick A. Gilbert, president and general manager of the Boston Electric Light Company; S. S. Dias, treasurer of the Boston Electric Light Company, and George B. Neal, treasurer and manager of the Charlestown Gas and Electric Company.

The report of the committee was accepted, and it was ordered that the resolutions presented be suitably engrossed and sent to the members of the families of the deceased.

The committee which was appointed to consider and report upon the address of the president submitted a report which was adopted as read.

Mr. J. F. Dusman, of York, Pa., presented resolutions to the effect that the association accepts the third progress report of the committee for investigating the photometric value of arc lamps, as read by Professor Matthews, the same committee to be continued, if possible, and if not, that another committee be appointed by the president to continue this work, and a vote of thanks extended to Professor Matthews for the excellent developments and investigations, as shown by this report.

On motion, the resolutions were unanimously adopted.

The papers on "Hot Water *vs.* Steam Heating," by J. F. Porter, P. H. Korst, C. R. Maunsell and D. F. McGee were then read.

On motion of Mr. Doherty, it was voted to hold the meeting of the association next year, 1903, in the city of Chicago.

The treasurer presented the report of the financial transactions of the association to and including January 1, 1902:

Balance in bank, January 1, 1901, and receipts during 1901	$12,163.58
Expenses	5,825.11
Balance	$6,338.47

President Doherty then expressed his thanks to the members who had so faithfully attended the meetings of the convention, and urged the attendance of as many members as possible at the convention in Chicago next year, after which the convention adjourned.

Mr. Louis A. Ferguson, the newly elected president of the National Electric Light Association, was born in Dorchester, Mass., August 19, 1867. After a course of instruction in the Boston public schools he entered the Massachusetts Institute of Technology, taking a full four years' course, and graduating in 1888 with the degree of Bachelor of Science in electrical engineering. Joining the same year the staff of the Chicago Edison Company, he has remained ever since connected with that enterprise, and has risen by various steps to become its general superintendent and, as well, the general superintendent of its subsidiary companies. His active work began in the underground department, and later he became assistant electrical engineer of the construction department of the company. Becoming in 1890 the electrical engineer, three years later his duties were increased to include the supervision of the contracting department. In 1897 he was appointed in general charge of the operating electrical engineering and contracting departments, giving him in this way the technical oversight of all the central station work in the city of Chicago.

The Chicago Edison Company has one of the finest plants in the United States, combining a large number of power stations and a most extended distribution of substations, as was fully described in the ELECTRICAL REVIEW for February 12, 1902.

Mr. Ferguson is a member of the American Institute of Electrical Engineers, and has been for the last two years vice-president of the National Electric Light Association.

Mr. W. V. Sweeton was the genial representative of the American Push-Button Telephone Company, of New York.

Mr. Wm. Coale, manager of the Sterling Electric Manufacturing Company, of Warren, Ohio, was a visitor to the convention city.

Mr. Frank McGovern was one of the late arrivals at the convention headquarters, representing Rossiter, McGovern & Company, of New York city.

The lamp department of the General Incandescent Arc Light Company was represented by Engineer Hallberg, Mr. F. C. Colwell also being in attendance.

Mr. F. E. Donahue arrived at convention headquarters in time to greet many friends. Mr. Donahue represents the Chicago office of the American Electrical Works.

Messrs. Edmund Dickey, general manager; M. Y. Hayden, superintendent; W. C. McGowan, selling agent for the South; A. J. Webb, eastern agent, and W. S. Schott, Chicago agent, were on hand to represent the Consumers' Carbon Company, of Lancaster, Ohio.

Among the apparatus exhibited by the Westinghouse Electric and Manufacturing Company at the convention may be mention integrating wattmeters, voltmeters and ammeters of various types, apparatus for synchronizing generators, automatic circuit-breakers and transformers.

"Kilfyre" and Mr. C. Henry Barney, assistant general manager of the Monarch Fire Appliance Company, were missed from the convention headquarters, as at the last moment Mr. Barney was unexpectedly prevented from being present. This dry chemical fire extinguisher, "Kilfyre," has just received the highest award, a gold medal, at the Charleston Exposition.

The Nernst Lamp Company, of Pittsburg, exhibited a handsome collection of Nernst lamps at the convention. The lamps were so arranged that objects of various colors, such as ribbons and samples of silk, could be illuminated first by incandescent light and then by light from the Nernst lamp, so that the accurate color values produced by the latter might readily be observed. These lamps are now manufactured in commercial styles and, it is understood, will immediately be put on the market.

One of the pleasantest events of the convention was a delightful luncheon given in the splendidly decorated dining parlor at the Grand Hotel on Thursday during the convention week. The hosts of the occasion were Messrs. N. T. Brady, Arthur Williams and E. A. Leslie, of New York. The guests were president-elect Mr. Louis Ferguson, and the retiring president, Mr. Henry L. Doherty, and Messrs. Samuel Insull, Converse D. Marsh, J. R. Lovejoy, Frederic Nicholls, Alexander Henderson, E. H. Mullin, Calvin W. Rice and James A. Ayers. A number of toasts were tendered to the officials of the National Electric Light Association and many interesting incidents of a more or less electrical nature were recited during this happy occasion.

TESTS OF THE EDISON STORAGE BATTERY.

AN INTERVIEW WITH MR. EDISON CONCERNING AUTOMOBILE POSSIBILITIES.

Mr. T. A. Edison was seen last Wednesday at his laboratory in Orange, N. J., and gave some account of recent tests that have been made with an automobile equipped with his new form of storage batteries.

"The first test," he said, "was made Friday last on a runabout machine carrying two passengers and equipped with twenty-one cells. This automobile had a very small battery space in it, and only that number of cells could be accommodated. The complete equipment of batteries, including the electrolyte, weighed 332 pounds. The route selected was in this vicinity, over the ordinary Jersey road, some macadam and some mud, some sand and some good pavement. In all seventy-five hills were ascended, ranging from two per cent to twelve per cent grades. Some little of the route was level, and of course some was down hill. Mr. W. G. Bee, who took the machine out, traveled sixty-two miles, and when he brought it back eighty-three per cent of the original speed could still be had from the batteries.

"We thought this was pretty good, but last Monday we took the same machine out, with the same batteries, fully charged, on a fairly level road and ran it to a standstill. It traveled eighty-five miles and stopped when the battery showed only 6.3 volts. The initial pressure from the twenty-one cells was twenty-nine volts. After running sixty-two miles up and down hill on the first day's trial, the pressure stood at twenty-two volts. Next week we are going to put out some big automobiles—five of them—and run them for a 5,000-mile endurance test over the country roads in this vicinity.

"The object of making this test is to find out for ourselves what this battery will do. We have not yet been able to notice any depreciation. It seems to make no difference to the cells whether they are discharged slowly or rapidly, and their output is much the same whether current is taken from them slowly or practically on a short-circuit. One curious effect we have noticed, though, is that the cells seem actually to work better in the automobile than they do on a test in the laboratory. Now this puzzled me for quite a while, until I discovered the explanation, which is very simple. You know the plates are composed of perforated boxes containing the active materials, and when the cell is standing still on the table little bubbles of gas may form behind some of these openings, thus cutting down to some degree the effective material exposed. On the automobile, though, these bubbles are shaken out, and this is the reason why, I think, we have found results on these runs which are even better than we had calculated they would be."

When asked when the battery would be put upon the market commercially, Mr. Edison said: "Our factory is now finished, the machinery is all in and we are making cells, but we are making them as yet for our own tests. If there is anything the matter with this battery, we want to find it out for ourselves and not let the public tell us about it. For this reason I am not going to let a single cell go out of the house until those trial automobiles have run 5,000 miles, and then brought home their batteries in as good shape as when they started."

The Independent Telephone Convention.

The annual convention of the Independent Telephone Association of the United States will be held in Philadelphia on June 24, 25 and 26. As yet, headquarters have not been selected, but the committee having this matter in charge is busily engaged upon it, and it is expected that in next week's issue of the ELECTRICAL REVIEW further details will be given concerning the choice of a place of meeting. The Hon. S. T. Sheerin, of Indianapolis, Ind., is the secretary of the committee in charge of the plans for formulating the programme. A number of interesting papers are expected to be read, and the usual discussion of matters pertinent to independent telephony and of interest to independent telephone companies and managers will be carried out.

Production and Distribution of Nickel, Cobalt Fluorspar and Cryolite in 1901.

The two principal sources of nickel are the nickeliferous pyrrhotite, the most widely spread of the nickel ores, and genthite, especially the garnierite variety. In this country the domestic product of nickel has been as a by-product from the lead ore of Mine Lamotte in Missouri, since the shutting down of the Gap nickel mine, in Lancaster County, Pa., about fifty miles west of Philadelphia, about ten years ago. This mine was worked from about 1863 to 1880, when work was discontinued because of the abundant supply of nickel matte from Canada. Traces and small amounts of the nickel minerals genthite and garnierite have been found in North Carolina, but not in commercially sufficient quantities, though a deposit of nickel ore averaging 1.5 per cent nickel is reported near Morgantown, Burke County. Similar occurrences of nickel silicate are found in Oregon, where the percentage of nickel ore is much greater than in the North Carolina minerals. The Oregon deposits are on Piney Mountain, in Douglas County, about three miles a little north of west from Riddles, a station on the Southern Pacific Railroad, and a high-grade cobalt ore deposit is being developed in the eastern part of the state.

Nickel ore is reported to occur in some quantity at the Congress mine, in Upper Nine-Mile section, about fourteen miles north of Keller, Ferry County, Washington. This section was formerly worked for copper and gold, but was abandoned. In the latter part of 1901 the claims were again taken up and are now being developed for nickel.

The first use of nickel was in making German silver. Nickel is also used extensively for coinage by the United States and many European countries. Nickel is also used, when welded upon iron and rolled into sheets, for making culinary utensils and other objects. The most important use of nickel is in making nickel steel, now used in large quantities in the production of armor plates, turrets, propeller shafts, bicycles, etc.

The amount of nickel imported and entered for consumption in the United States in 1901 was 117,364,337 pounds, valued at $1,847,166, as compared with 57,955,988 pounds of nickel matte, etc., valued at $1,323,630 in 1900. The amount of nickel produced from matte and ore imported into the United States was 10,497,097 pounds, worth between $5,000,000 and $6,000,000. There was a decided increase in the production of nickel from New Caledonia ores in 1901. The price of nickel oxide has been about five cents lower per pound than the metal, while the cobalt oxide has been sold at $2.20 a pound. The nickel industry is increasing rapidly, and there has been, also, a decided increase in the amount of nickel used in the United States. The export of nickel oxide and matte from the United States in 1901 was 5,869,655 pounds, as compared with 5,869,906 pounds in 1900.

THE ENGINE BUILDERS' ASSOCIATION OF THE UNITED STATES.

INTERESTING MEETING OF THIS ASSOCIATION AT PITTSBURG, MAY 22 AND 23.

The Engine Builders' Association of the United States held a general meeting at the Schenley Hotel, Pittsburg, Pa., on May 22 and 23. The first day's proceedings were opened by an address by President W. M. Taylor, of the Chandler & Taylor Engine Company, of Indianapolis. This was followed by a paper on "Engine Forgings," by H. F. J. Porter, of the Bethlehem Steel Company. Mr. Porter's paper was of considerable length and great interest, and described in full the work of specialization, which has resulted in ability to build the gigantic solid steel parts of modern engines and dynamo machines. Mr. Porter described the various processes in the manufacture of steel, the casting of the ingots under hydraulic pressure, and their forging by means of hydraulic presses. His paper was a valuable addition to the literature of the subject.

With the discussion of this paper, the first day's session ended.

On the second day a paper entitled "The Engine Requirements for the Parallel Operation of Alternators" was read by Mr. E. M. Tingley, of Pittsburg. This paper is given below. The other two papers upon the day's programme were respectively entitled: "Piping Materials for Steam Plants," read by Mr. John H. Berryman, of Chicago, and "The Requirements for the Paralleling of Alternators as Viewed by Engine Builders," read by Mr. H. M. Longwell, of Pittsburg. Mr. Longwell's paper was a masterly discussion of the problem, and the fact that two papers bearing upon this important subject were read before an association of engine builders is one that serves to show how great an interest is now being taken in the requirements of electrical machinery by makers of motive power apparatus.

In the evening a largely attended banquet was enjoyed, this bringing the session to a close.

ENGINE REQUIREMENTS FOR THE PARALLEL OPERATION OF ALTERNATORS.

BY E. M. TINGLEY.

In connection with extensive work in electrical engineering, the Westinghouse Electric and Manufacturing Company has from time to time been called upon to give information and suggestions regarding engine requirements for the parallel operation of engine-type or direct-connected alternators. This information has been crystallized into the form of a specification, which is often embodied in the contract for generators or sent to the engine builders for their information or assistance.

The specification is entitled "Engine Requirements for the Parallel Operation of Engine-Type or Direct-Coupled Alternators and for Engine-Type Alternators Driving Rotary Converters."

The engine driving the alternators should have the following characteristics:

a. The engine governors should be so constructed that there is no tendency to cause a periodic transfer or surging of the load between one engine and another. This tendency may originate in the angular variation of velocity in different parts of the revolution which is common to all reciprocating engines, or to a sudden variation of load which will affect each governor in a slightly different manner, or to other causes that lead to a non-uniform speed. The engine governors should not be sensitive to such disturbances nor maintain or increase them.

The effect on the engines of a periodic transfer of load occasioned by hunting between two engines running in parallel is somewhat similar in effect to throwing the load on and off of a single engine at short intervals which may be measured by one or several pulsations in the combined turning efforts applied to the engine shaft.

In some extreme conditions the pulsations of load may amount to more than the normal capacity of either engine. With no extreme load one engine may then alternately drive the other, which will evidently be a more severe condition than if the load were only applied and removed from a single engine.

If, under any case of pulsating load the engines do not tend to accentuate the pulsations in turning effort and speed, then a condition favorable to parallel running is attained.

b. Variation of the rotating part of the generator through the revolution at any constant load not exceeding twenty-five per cent overload should not exceed one-sixtieth of the pitch angle between two consecutive poles from the position it would have if the motion were absolutely uniform at the same mean velocity. The maximum allowable variation, which is the amount the rotating part forges ahead plus the amount which it lags behind the position of uniform rotation, is therefore one-thirtieth of the pitch angle between two poles. Generally this is obtained by the use of a heavy flywheel.

In a two-pole machine this variation is equivalent to three degrees as measured on the circumference of the rotating part; in a four-pole machine it is one and a half degrees, and in a six-pole machine one degree, or as the number of poles increases the permissible angular variation decreases.

c. The engines should have practically the same characteristics of speed regulation that the power delivered to their respective generators may be proportional to the load, that is, the same load on any engine should produce the same percentage drop in its speed. This is most readily obtained in engines in which at full load the speed drops from three to five per cent below the no load speed, as a slight change in adjustment of the governors will have less relative effect than in engines in which the speed drops only one per cent under the same variation of load.

d. The use of governors which are adjustable while the engine is running is recommended. Slight adjustments of speed may then be made which will facilitate synchronizing the alternators or changing the load carried by the engines.

It may be noted that there is no attempt to tell how these results are to be obtained. This is a problem for the engine builders.

Paragraph *a* deals principally with the engine governors as the source of most of the difficulties.

The alternators simply transform mechanical energy and electrical energy and their effect in connecting engines together is precisely the same as any other elastic coupling, and, as far as the engines are concerned, should be considered as such. The force tending to keep the generators in step is sometimes termed their synchronizing power.

It is sometimes contended that this force should be made stronger or weaker to accommodate assumed engine conditions, but this can not be done without extensive changes in the generators. To make the force weaker reduces the inherent voltage regulation of the generators, and to make it stronger adds considerably to their cost.

Some of the effects of pumping may be reviewed by considering the simplest case in which pumping occurs—*viz.*, when two alternators are in parallel with no external load. If the alternators will work in parallel under this condition, they will usually work together under load or with one or more additional units. This is also the usual condition of starting.

Either generator or engine alone on an external load may perform in a perfectly satisfactory manner.

Before connecting the generators together they should be brought exactly in step or in the same phase and as nearly as possible to the same speed as indicated by synchronizing lamps or synchroscope.

When the two generators are connected together at precisely the proper instant, nothing unusual will happen for a few seconds, but soon the ammeters will show cross-currents between the alternators as pumping commences, indicating that the generators are no longer in the same phase, or there is an angular difference between the machines which did not exist at the moment of synchronizing. If the ammeters are very sensitive, they will show that the cross-currents pass to zero at each pulsation. If they are "dead-beat," as most switchboard instruments are now made, they will indicate a steady flow of current with perhaps small pulsations.

A sensitive wattmeter will also indicate that energy flows from one generator to the other, or one unit acts alternately as motor and generator to the other.

The voltage on the two machines is lowered by these cross-currents, and is pulsating and therefore is unsuitable for lighting service. Synchronous motors and rotary converters connected to these generators may pump, drop out of step, or otherwise cause trouble. The generators may also grow warm on account of these cross-currents or give out sounds, indicating unusual internal mechanical forces. If the pumping increases in severity, fuses may blow, circuit-breakers open, or the generators finally pump entirely out of step. The engines meanwhile may perhaps not show that anything unusual is happening while the pumping continues, leading some to assume that the trouble is all in the generators, while it is only the result that is apparent and not the cause.

If, however, as in some cases, it is possible by looking through the arms of the flywheels to see the change in relative angular position of the two machines, it will be seen that there is an actual vibration between the two machines, such as might be expected to occur with an elastic coupling between the engines. These disturbances are usually traceable to the engine governor, since if they are not maintained by some regular recurring change in steam distribution they would soon die out on account of frictional resistances to such oscillation.

If the case is considered where a load is thrown on and off a single engine and generator by a suitable switch at regular recurring intervals, the governor may lag in its correcting effect, and then again overshoot the mark in maintaining an average speed. If this periodic load is applied or removed at the instant the governor and engine begin to recover from one of these excessive speed corrections, the effect is maintained or it is cumulative and the engine varies periodically in speed.

Now, if this intermittent load is replaced by another engine and generator there may be a resonant action between the governors on the one hand and the synchronizing force between the generators and inertia of the rotating parts on the other, which will produce the same action on the governors as the intermittent load.

The oscillations may be started either by the angular variation in speed which occurs in all reciprocating engines, or to changes of load.

Usually additional flywheel effect in the rotating parts decreases the tendency to pumping. It is only when additional flywheel capacity increases this resonant effect that the additional flywheel is objectionable.

In place of one or more generators, rotary converters or synchronous motors may be substituted and the effect will be the same as far as the generators are concerned.

To assist the engines in parallel running, it is now usual to apply dampers to the poles of the generators and rotary converters and synchronous motors. Dampers do not endure parallel running, nor are they absolutely necessary, as is shown from experience. The best and most effective form of damper may not reduce pumping to a reasonable amount in some cases, and in other cases parallel operation is accomplished practically without dampers.

In continuing our mechanical analogy, if the generators in connecting the engines are similar to an elastic coupling, then the dampers are similar in action to a dash-pot in reducing the yielding of that coupling to varying forces. Where the best form of dampers are ineffective in reducing pumping to an allowable amount, it means that the impulses from the engines are greater than can be corrected for in the generators. The steam distribution, inertia of reciprocating parts, or the effect of gravity on the reciprocating parts in vertical engines all contribute to the varying angular velocity.

Paragraph *b* limits the angular variation from uniform velocity solely to limit the cross-currents between generators and rotary converters to what is considered a reasonable amount. If the angular variation is no larger than specified, the performance will be satisfactory. The angular variation is usually calculated from the variations in crank effort and the flywheel capacity of rotating parts, since its correct measurement is exceedingly difficult.

The objection may be raised that the allowable angular variation is exceedingly small, especially on machines with a large number of poles. However, other authorities have given a value one-sixth smaller than that which we have adopted.

Engines running with cranks in step will give better performance as regards themselves than with cranks out of step, especially if the angular variation is large, since the angular difference between two generators may be at all times smaller than the difference from absolutely uniform rotation. With a large angular variation, however, the operation of rotary converters will be unsatisfactory. With the engine cranks out of step there may be larger cross-currents between the generators, but the fluctuation frequently in the outside circuit will be smaller than before, since it will be the resultant action of two or more engines.

In some cases the angular variation may be such that while parallel operation is possible, rotary converters or synchronous motors are inoperative or unsatisfactory.

Paragraph *c* refers to governor characteristics by which the load is properly divided between two or more engines. The same precautions would be observed if the engines were carrying the load together by means of a belt or other drive instead of by means of electrical generators. What is really desired is that each engine shall at all times exert its share of the total driving effort or torque, a condition which is so readily obtained in water-wheels. It is absolutely necessary to proper division of the load in parallel running. Of course it is most readily seen that in engines in which this speed variation from no load to full load is from three per cent to five per cent instead of one per cent, that this condition is most easily obtained. If this constant torque characteristic can not be obtained by a suitably designed governor, it may be possible to obtain it through some auxiliary devices.

Adjustable governors are recommended in paragraph *d* for the purpose of transferring the load from one generator to the other in order that the load may be readily cared for at the switchboard, or reduced so that the generator switches may be opened without injurious arcing. Usually the engine governors will vary in their own adjustment and it becomes necessary to correct this from time to time in order to divide the load properly, since all the governors may not regulate the same throughout the total range of load. Adjustable governors also enable an unloaded engine to be synchronized with a loaded engine.

The parallel operation of alternators driven by water-wheels has been uniformly successful and the same should be true of engine-driven alternators. Success, however, has been the rule and by suitable governors and ample flywheel capacity there is no doubt but that all cases in which parallel running is required it may be accomplished.

Reviews of Current Engineering and Scientific Literature.

Giving Concisely the Substance of Important Papers in the Scientific, Electrical and Engineering Press of the World.

Direct-Current Power Transmission.

A very interesting installation is that for the transmission of power from the falls of the Rhône, at St. Maurice to Lausanne, Switzerland. From 10,000 to 15,000 horse-power is transmitted by direct current, the distance being fifty-six kilometres (34.7 miles). At present the installation is working up to a total capacity of 5,000 horse-power. The system used is that of M. Réné Thury, making use of constant-current dynamos and motors of the same type, a group of each being connected in series at each end of the line. The maximum tension runs up to 23,000 volts. At Lausanne the motors are direct-coupled to three-phase 3,000-volt alternators for the distribution of current for lighting and power in the city and its neighborhood. The plant is operating with great satisfaction and in a highly successful manner.—*L'Industrie Electrique* (Paris), May 10.

A New Electricity Meter.

Messrs. W. M. Mordey and J. L. Fricker, of London, recently exhibited before the Royal Society an ingenious and simple electricity meter suitable for both direct and alternating currents. The meter is simply a clock with the hair-spring of the balance wheel removed and replaced by one or more pieces of iron moving in the magnetic field created by a pair of coils traversed by the current feeding the lamps. When only one lamp is in action the field is very weak, and the clock resembles one that has a feeble hair-spring —in other words, it goes very slowly. As more lamps are lighted the field becomes stronger and the rate of vibration quickens, the period of the balance being inversely as the current flowing. In the meter exhibited the balance wheel was of slate, carrying several parallel iron wires on its surface. This was partly enclosed in two coils like a galvanometer and, owing to the pressure of the pallets of the ratchet escapement, it always stopped when current was cut off in such a position that the first action of the current when turned on was to set it in motion. The balance wheel shaft is carried on a special step jewel. In order to relieve the jewel of pressure a silk fibre suspension is used, taking the whole weight of the revolving parts off the jewel. Of course, this is an ampere-hour meter, but for use on constant-pressure circuits the counters may be made to indicate directly in kilowatt-hours. The constant is the same for direct current and all ordinary frequencies of alternating current. The clock can be made to run for about three months on one winding in ordinary service. It is claimed that the errors are well within two and one-half per cent.—*Engineering* (London), May 16.

Calcium Carbide as an Insecticide.

For several years past the vineyards in the important wine-growing district of Beaujolais have suffered greatly from the attacks of numerous flying insects, the most important of which is known as the pyralid. Last year a series of experiments was carried out in one of the large vineyards to see if the insects could be caught by bright lights burning at night. An apparatus was constructed, consisting of an acetylene generator holding about six ounces of calcium carbide. Over this was a circular metal dish about twenty inches in diameter, and over this at a height of about eight inches a single acetylene jet giving a small, bright light at about ten candle-power. This light the carbide was sufficient to keep burning for six or eight hours. In a basin a layer of water was placed, and on top of this a layer of kerosene or some other cheap oil, of which about two fluid ounces were required. These machines were set up about 550 yards apart and were set in action at dusk, preferably on dark nights. On the first night one lamp caught 4,600 pyralids and 218 moths of other kinds. During July the lamps averaged 3,200 insects per lamp per night. The expense of the lamps is reported to have been two cents per night each, or about two and one-half cents per night per acre. It is said that this method of catching noxious insects is more efficacious than any method which has been tried before.—*Electrical Review* (London), May 9.

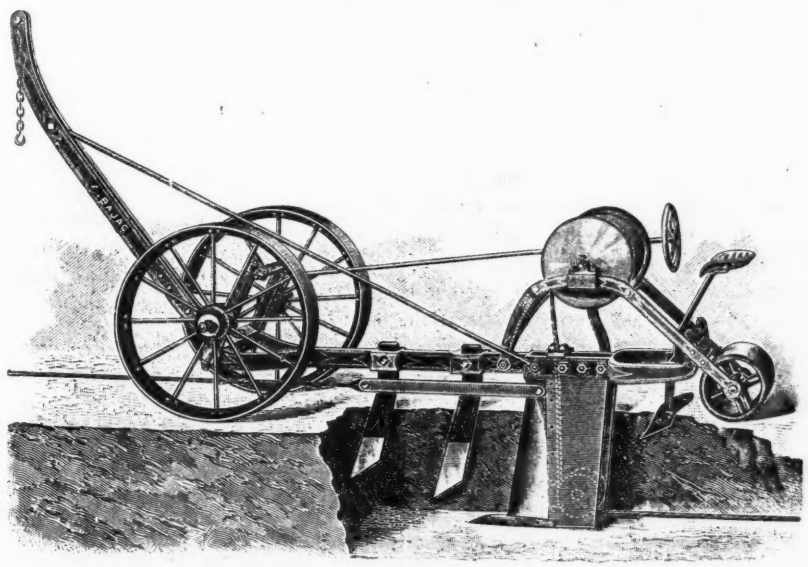
Earth Currents.

An interesting paper by Mr. E. Guarini discusses the subject of earth currents noticed in telephone and telegraph wires on grounded circuits. Currents seem to be produced during storms by charging and discharging conductors through atmospheric electricity. Induction currents are developed from neighboring wires, and other currents are set up by the chemical action of damp earth on the electrodes establishing communication with the ground. In addition to all these are the telluric or earth currents which pass through grounded circuits permanently, but constantly vary in nature, intensity and direction. Sometimes they become so strong as to render telegraphic transmission impossible. Their origin as yet is unknown, notwithstanding all that has been written on the subject. Magnetic disturbances which accompany outbreaks of spots on the sun are always attended by intense earth currents. Exceptionally strong currents have been observed after earthquakes, and for several days after storms and violent gales. In Spain last year Don José A. Perez del Pulgar made some observations of great interest on earth currents. The lightning-rod ground plates of an observatory were connected through a galvanometer which was properly protected against any influence of atmospheric currents. He found that the oscillations of the galvanometer are more frequent and more intense when clouds are being carried past by the wind at a high speed; that variations in intensity of sunlight seem to cause variations in the currents; that on damp and foggy days there seems to be no current; that the wind appreciably influences the intensity of earth currents. Notwithstanding these observations, their author was unable to devise a satisfactory hypothesis of the nature and origin of the currents. A relay galvanometer is described, whereby the direction of the earth currents can be recorded automatically upon a sheet of paper, and it is suggested that the indications of such apparatus studied in connection with meteorological and magnetic observations might lead to some definite conclusions.—*Electrical Review* (London), May 16.

A Cable-Laying Plow.

A most extraordinary engine is illustrated in a French contemporary. It con-

sists of a plow for burying an armored cable to a depth of two to three feet below the surface of the ground without the necessity for digging a trench. The machine consists of a powerful subsoil plow of peculiar construction, adapted to be driven by a cable attached to a winding engine or to be dragged by a large team of horses. The frame of the plow rests on three wheels, and carries the coil of cable to be laid. A coulter blade of great strength first opens a deep slit in the ground to the proper depth, this being followed by another coulter blade of somewhat wider shape, which in turn is followed by the hollow plowshare. In this is a pulley under which the cable runs from the reel to the bottom of the trench. Following this is a share or



A Cable-Laying Plow.

mould-board which turns the earth back into the trench, and last of all a roller which tramps it down securely over the buried cable. It is intended to use this apparatus to lay a subterranean cable for telegraphic purposes across the Sahara Desert, between Gabés and Lake Tchad. Curiously enough, it has been built for the French Wireless Telegraph and Telephone Company.—*L'Industrie Electrique* (Paris), May 10.

Electrical Process for Preserving Wood.

A process adapted not only to preserve railway ties, telegraph lines, etc., but also to use for small pieces of wood employed in cabinet-making, etc., has recently been put to work in Germany. The apparatus consists of a tank of convenient shape to receive the wood to be treated, on the bottom of which is laid a lead plate connected with the positive pole of a dynamo. The wood to be treated rests upon this plate, and is covered by another plate connected with the negative pole. The tank is filled with a solution of resin in borax, and carbonate of soda. The action of the current causes the sap to exude from the wood and flow up to the surface where it can be skimmed off, the antiseptic solution taking its place. After a treatment of from five to eight hours' duration, the wood is withdrawn from the bath and dried either in the open air or in kilns. The current used is at a pressure of 110 volts, and energy is consumed at the rate of about one kilowatt to thirty-five cubic feet, or 420 feet board measure of wood. It is somewhat less than this when the wood is freshly cut and still full of sap. The temperature of the bath varies from forty to forty-five degrees centigrade.—*Revue Technique* (Paris), May 10.

High-Potential Direct-Current Dynamos.

Some of the most remarkable dynamos lately constructed have been set to work on the St. Maurice-Lausanne transmission line in Switzerland. Each of these machines is capable of generating direct currents under a pressure of 25,000 volts. The apparatus is a two-pole dynamo resembling externally a modern alternator with radial poles. The field magnet is of laminated iron and revolves inside a ring built in two parts, which constitute the armature. The latter is consequently fixed, while the field revolves. The armature coils are forty-eight in number, wound in slots in a stationary iron ring. They are insulated by a specially prepared paper trough. Each coil contains 500 turns of wire twenty mils in diameter, insulated with silk. There are thus in all 24,000 turns in the armature, which is capable of a normal output of one ampere; its resistance is about 700 ohms. The commutator is formed of ninety-six segments, air insulated. It is also fixed and two brushes run upon the inner surface of it, turning with the shaft and being connected to collector rings for leading off the current. To avoid the formation of arcs between the segments of the commutator, which have a difference of potential of 500 volts between them, a blower is provided, feeding two jets which turn with the brushes and blow a powerful stream of air upward from the interior of the commutator. The machine is separately excited, the air-pump being attached to the pulley of the exciter. This machine is, of course, very carefully insulated from the earth, as is the rheostat which controls the exciting current. The machine requires eight amperes at eighty volts for excitation, and gives 25,000 volts at its normal speed, 600 revolutions per minute. The diameter of the revolving field is seventeen inches, and the output thirty-four electrical horse-power over an ordinary telegraph line of iron wire 148 mils in diameter. One of these machines has transmitted twenty-six effective horse-power for 218 miles, using the ordinary earth return. A Planté condenser apparatus is now under construction at Geneva, so arranged that when charged by this machine it will give a discharge current of 250,000 volts.—*L'Electricien* (Paris), May 10.

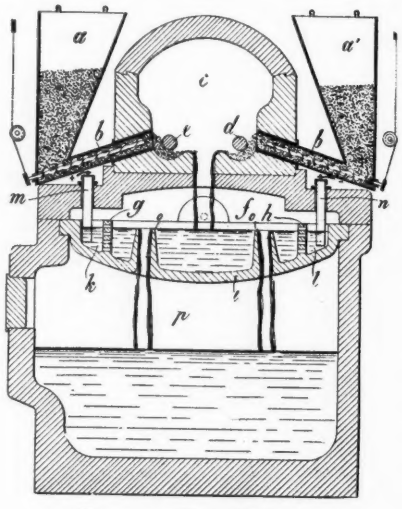
Is the Electrical Supply Dealers' Association a Trust?

It is stated that a complaint will be filed with the Attorney-General of the United States by independent electrical supply dealers in Chicago, asking the Attorney-General to proceed against the Electrical Supply Dealers' Association under the Sherman law, and alleging that the association constitutes a trust under the definitions of that law. It is further alleged that the charges which are to be made will recite that this association raises or lowers the market price of electrical supplies, and that it maintains an offensive and defensive alliance against competitive dealers.

The Electrical Supply Dealers' Association was organized about two years ago to promote trade, secure harmony in prices, and accomplish other beneficial objects in the electrical supply business. It is not believed that any definite action has yet been taken.

Electrical Patents

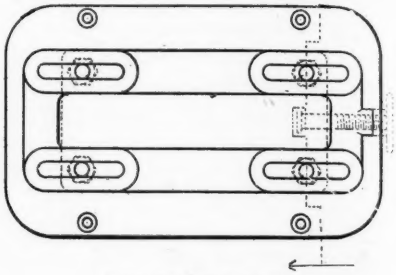
The reducing fusion of difficultly-fusible materials (ores, metallic oxides and the like) by means of the electric current has been effected, with the exception of certain special cases, such as the raw materials for glass and calcium carbide, in one of two ways. Either the substance to be fused has been used as a resistance in the circuit, in which case it forms itself the resistance or is in intimate contact with another resistant material, or the substance to be fused is introduced between the poles of an electric arc and is heated by the arc itself. The second method, which considerably exceeds the first in intensity, has already been used for melting the raw materials in the manufacture of glass. While heating by means of the arc itself has the advantage that the substance is heated very rapidly to a high temperature, so that immediate fusion follows, on the other hand the so-called "resistance heating" affords a simple and sure method of working, so that its application to the manufacture of glass has much to recommend it. Mr. August Voelker, of Ehrenfeld, Germany, has patented in this country an improvement in the manufacture of glass by electrical heating, which consists in clearing the molten mass—that is to say, in removing the air bubbles therefrom—by converting it into an electrical resistance after it has been melted by the arc. In this manner the clearing process may be hastened. The process is as follows: After the raw materials have been fused in the electric arc, in a crucible, or the like, in the known manner, the molten mass is poured or allowed to flow into a tank or chamber, and into it is introduced a pair of electrodes, by means of which a strong electric current is passed through the melted mass, which is a feeble conductor in the first instance or becomes a conductor of the second class. By this means, according to the strength of the current, a more or less powerful but steady and uniform heating of the mass of glass is effected, so that the latter becomes mobile, and the gas and air bubbles in it are able to rise and escape easily. This clearing process is of very short duration, and the uniformity of the heating is of essential importance to the product. The accompanying drawing shows in vertical section a furnace adapted for this invention. The hoppers *a a'*, containing the raw material for making the glass, communicate with the fusion chamber *c* through upwardly sloping passages containing the conveyors *b*. In the chamber *c*, which is constructed of fireproof material, such as chamotte, are provided the electrodes *d e*, one between each inlet for the raw material and the outlet for the same. Under the chamber *c* is arranged the refining pot *f*, which is also constructed of fireproof material. In this pot *f* are provided perforated partition walls *g h*, preferably of chamotte stone, forming compartments *k l*, in each of which dips an electrode *m n*, preferably of carbon. Rising from the bottom of this refining pot there are one or more overflow pipes *o*, open at the top. A basin *p* is provided under the refining pot to collect the molten glass. The raw materials for making the glass are fed continuously by means of the conveyors *b* into the



Electric Glass Furnace.

chambers *c* from the hoppers *a*. Because the materials are discharged into the furnace from below and at the sides thereof between the carbon electrodes *d e* and the furnace walls, as shown in drawing, it is possible to avoid contaminating the glass in the refining pot *f* with dust, and at the same time the walls of the furnace are protected from the intense heat of the electric arc, since this never strikes upon the walls themselves, but always on the raw material which lines them. The electric arc between the electrodes *d e* thoroughly melts the materials. The molten glass flows from the fusion chamber into the refining pot *f* into which the electrode plates or bundles *m n* of suitable dimensions are placed. A strong electric current is supplied to these electrodes, and the glass thus clarified flows down the overflow pipes *o* into the basin *p*. The reason for not introducing the electrodes directly into the main tank *i* is that the contamination and coloration of the glass by particles from the electrodes may be avoided. The strength of the current required depends on the size of the furnace and on the composition of the material in question. It may, however, be assumed that five amperes for each square millimetre of electrode surface is a fair maximum.

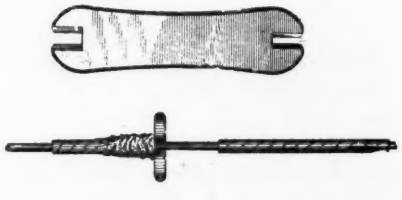
Mr. Fred B. Duncan, of Akron, Ohio, has devised a very simple means for adjusting and holding dynamos or motors on their bed-plates, his object being to prevent any tendency of the machine being twisted out of alignment by the



Dynamo Bed-Plate.

tightening of the belt. The bed-plate is constructed of substantially the usual form, having longitudinal slots that taper from their lower toward their upper ends. The feet of the dynamo or motor have the usual openings through which the shanks of the bolts are passed. The bed-plate and feet are provided with the usual adjusting screw, but the bolts by which the two parts are secured have pyramidal heads that accurately fit in the slots. When these bolts are drawn tight by their nuts, the rectangular and pyramidal heads draw firmly into their seats and accurately centre the round parts of the slots, thus at all times securing the feet against any twisting on the bed.

A handy little device for stripping insulation from wire has been patented by Mr. Clarence C. Sibley, of Perth Amboy, N. J. As shown in the accompanying illustration, a flat metal plate is employed, the ends of which are bifurcated to form

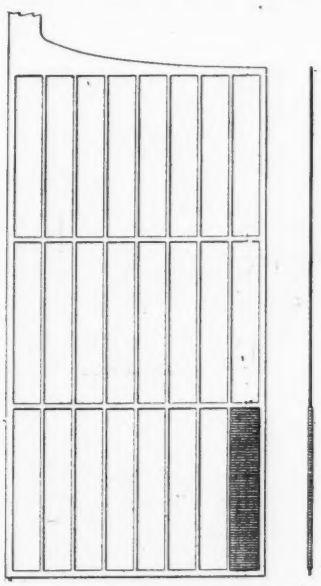


Insulation Stripper.

spaced jaws, the jaws at one end being further apart than at the other, so that the device may be used on different sizes of wires. The inner edges of these jaws are sharpened so that they will readily cut the insulation. The manner of using the device is as follows: The wire is forced into the slot between the

jaws, thereby cutting the insulation on opposite sides of the same, after which the implement is rotated to completely cut the insulation around the wire. The wire is then pulled through the slot, and as the insulation bears against the face of the tool it will be stripped from the wire.

Mr. Thomas A. Edison has just obtained two more patents on galvanic or storage batteries, both of which he has assigned to the Edison Storage Battery Company of New Jersey. The first relates more particularly to the use of a particular kind of finely divided iron employed as one of the elements. This iron is prepared by subjecting sheets of pure Norway iron to a rather high temperature in a muffle in the presence of air, whereby a thin scale will immediately form after the sheet has reached a red heat. This scale is then immediately detached by withdrawing the plates and by bending or striking them so as to dislodge the oxide, after which the plates can be returned again to the muffle for further oxidation, which operations are repeated, the scale being successively formed and removed as long as the plates can be practically handled. The scale thus formed is preferable to the scale which would be formed by leaving the iron sheets in the muffle for a long time, since in the latter case a larger proportion of the scale will be raised to a higher or ferric state of oxidation, which oxide is not reducible by the current, but by permitting the sheets to remain in the muffle only until they reach a red heat and by then immediately detaching the scale oxide the latter will be largely of a low condition of oxidation and be capable of electrical reduction, and hence will be suitable for effective use in a reversible galvanic cell. When a sufficient quantity of the scale has been thus made, it is reduced to a fine powder—such, for example, as may be passed through a screen of 40,000 meshes per square inch, and is then mixed with flake graphite. Preferable proportions are eight parts, by weight, of the scale oxide and two parts, by weight, of flake graphite. The mass of the scale oxide and flake graphite is then packed under pressure in suitable perforated supporting receptacles or plates made, preferably, of nickel or nickel-plated iron or other metal, and is subjected for a long time in an alkaline solution to the reducing action of the current until the oxide is converted to the metallic form, whereupon the electrode will be ready for use. The other patent covers a construction which is economical to manufacture and has the combined advantages of lightness, compactness and strength. In this case, a thin grid or plate is made use of which is unaffected by the electrolyte and which is provided with a plurality of openings therein, preferably rectangular in form, arranged in horizontal rows quite closely together, and the active material of the plate is carried within perforated cups or pockets, which in turn are securely fastened in said openings. Preferably each cup or pocket which carries the active material is made of two sections, one engaging within the other and which after being introduced within the proper receptacle of the plate or grid are subjected to pressure so as to be firmly compressed together and at the same time to be intimately locked in position. At the same time the engaging pressure acts to compress the mass of active material to intimately engage it with the metal of



STORAGE BATTERY PLATE.

the cups or pockets and within the perforations therein, so as to be effectively acted upon by the electrolyte during charging and discharging operations, and also to make good contact between the active material and the metal. When the two active materials of the battery are both of such form that they can be carried in cups or pockets, as explained, secured in position within openings formed in grids or plates, the grids or plates carrying the active materials are alternately arranged in a suitable supporting cell, made, preferably, of sheet metal, and are insulated mechanically and electrically from each other, preferably by means of thin corrugated sheets of hard rubber, thereby producing a very light and rigid construction, after which an insulating cover is applied to each cell, the electrolyte being then introduced, and finally a viscid insulating material is preferably flowed over the cover so as to make the cell absolutely water-tight, except for the usual gas vent therein. If, however, the battery is of the type wherein only one of the active elements is in a pulverized form suitable for being received in a perforated pocket or cup, the other element being, for example, a plate on which a metal from the electrolyte is deposited electrolytically—as, for instance, in reversible batteries using an alkaline zincate electrolyte, the plates or grids carrying the active material in the perforated pockets or cups can be alternately arranged with respect to the other electrodes in an enclosing case, being separated therefrom by corrugated hard rubber partitions, as explained, and the case being provided with a water-tight cover having the usual air vent therein.

An Electrical Adjunct to the Militia.

On the evening of Thursday, May 15, the Thirteenth Regiment, N. G. S. N. Y., was reviewed at the armory in Brooklyn, N. Y., by his Honor Mayor Seth Low. After the preliminary events, in which Mr. Low participated, the *piece de resistance* of the evening was the work of the electrical company, Company M, under the command of Sergeant M. C. Sullivan. This company is being recruited from the high schools and academies of Brooklyn, and the young men comprising the personnel are very enthusiastic in carrying out their work. These are special students in electricity, chemistry and physics, and there is no doubt but that in time this picked body of young men will prove a valuable adjunct to the manœuvres of this heavy artillery regiment. The event of the evening was an allegory simulating a night attack upon the harbor of New York. A miniature warship was constructed of canvas and boards, which was carried across a line of torpedoes which had been placed by the company earlier in the evening. When everything was in readiness taps were sounded and all the lights were extinguished in the vast auditorium. Presently a searchlight, which was under the direction of one of the company men, located the ship proceeding slowly across the space occupied by the torpedoes. There was a blinding explosion and a part of the ship disappeared. As it was slowly drawn across in the intense darkness, the searchlight locating it at intervals, the remaining torpedoes were exploded, the effect being realistic and spectacular in a very high degree. The Mayor pressed the buttons which connected the contacts of the mines, and was highly interested in all the work done by the electrical company.

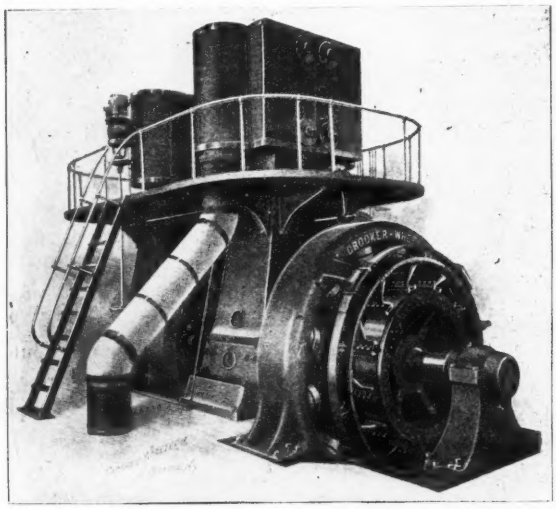
There was no attempt made to do anything of an ornamental or artistic nature. The crudest every-day appliances were made to serve for this work. In constructing the firing box an ordinary soap box was employed, the binding-posts being made of wire nails, and the leads, of ordinary bell wire, were reeled on two long wooden skids. The current was taken by hooking on to the 110-volt light circuit in the building, an incandescent lamp, placed in series in the torpedo circuit, giving the illumination necessary to locate the keys on the firing box.

INDUSTRIAL SECTION.

ILLUSTRATED DESCRIPTIONS OF NEW AND STANDARD ELECTRICAL AND MECHANICAL APPARATUS.

Engine-Type Generators.

In the accompanying illustrations is shown a line of direct-current engine-type generators manufactured by the Crocker-Wheeler Company, of Ampere, N. J. In developing this line of machinery, it has been the aim of this company to adopt such ratings and speeds as would conform most nearly with the best practice in the design of steam engines suitable for use in either lighting or power plants. For the higher voltage generators of this type (550 volts) used for railway work, particular care has been taken on account of the exacting requirements of this work, so that these machines might embody only well-proven elements of dynamo construction which the best engineering experience could suggest.



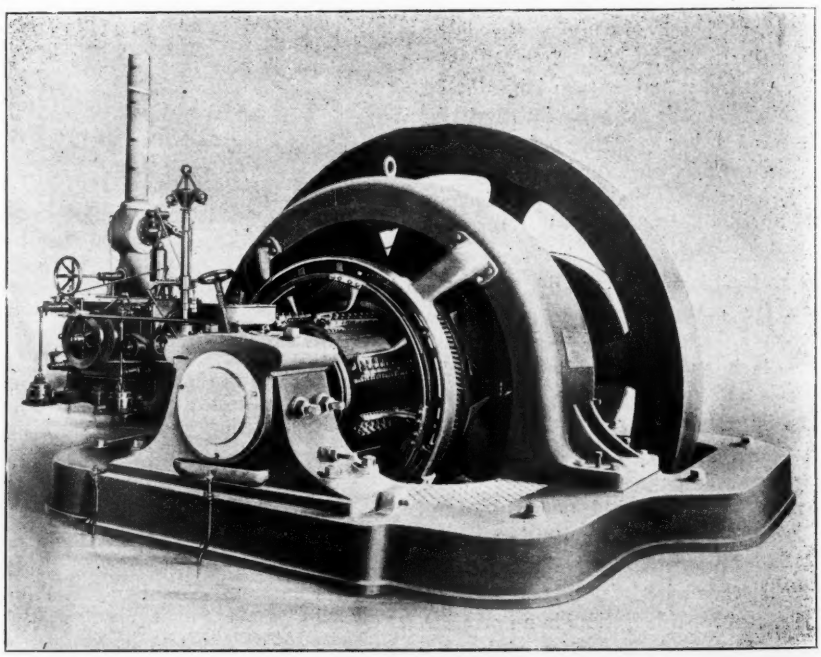
RAILWAY GENERATOR DRIVEN BY VERTICAL ENGINE.

The iron and steel used for the field and armature are selected with special reference to their magnetic qualities, the other materials being selected with reference to their suitability for duty. Compactness, simplicity, strength and endurance, low current density in windings, commutator, brushes, and other conducting parts, ample cooling surface and adequate means of ventilation, with a low armature reaction and variation of brush lead, are the essentials which the design of these machines has aspired to.

The magnetic frame is a cast-iron ring of patented girder construction, divided horizontally, the two halves being fastened together by dowels let into the frame. The lower half of the magnetic frame is provided with feet that are drilled to receive the holding-down bolts, and are fitted with leveling screws for accurately adjusting the position of the field magnet frame. The poles are round and of steel casting welded into the frame in such manner as to ensure a perfect magnetic joint. In order to produce the best distribution of the magnetic flux where it enters the armature and to give a comparatively large air-gap, each pole is fitted with a removable shoe. This large air-gap is a valuable feature, as an unequal settling of foundations or perhaps the ordinary wear of the journal boxes might in time permit the armature to become slightly out of centre with respect to its field. This would throw the machine out of magnetic and electrical balance by permitting an unequal distribution of magnetism from the different poles to the armature. Such a lack of balance gives rise to excessive heating and sparking, with the consequent trouble in regulation, causing a powerful attraction of the armature toward the nearest poles, straining the shaft and causing heating of bearings.

The field coils are easily removable from the poles, and the windings are well coated with high-grade insulating varnish. The field coils are wrapped with a protective covering to guard against mechanical injury, and the terminals are substantially made with ample contact area, and are properly marked to ensure connections being correctly made.

The armature is of the iron-clad type, the core being formed of toothed laminations made of mild steel. The armature spider is cast in a manner to avoid internal shrinkage and strains, the laminations being held to the spider by a large number of dovetailed connections accurately machined to an exact fit in the larger sizes, and in the smaller machines by keys and bolts. The slots have parallel sides with round bottoms and open tops. The windings are thoroughly protected against mechanical injury, and ample ventilating surface is provided in the core and at each end flange. The windings have no joints, except where connected to the commutator. The conductors consist of solid copper wires with cotton covering, varnished. In the slots are placed troughs of insulating material shaped previously upon a form,



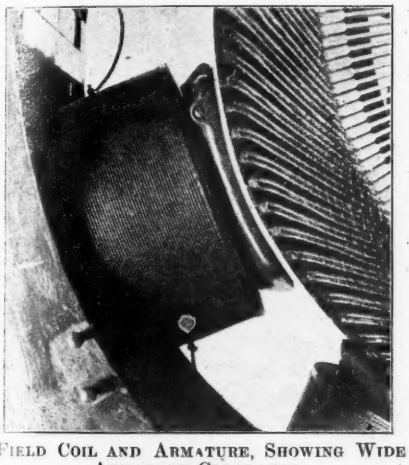
300-KILOWATT DIRECT-COUPLED GENERATOR.

and these, in addition to the insulation wrapping on the coils, furnish further mechanical and electrical protection.

The commutator bearings are of the

ONE OF THE FIELD COILS.

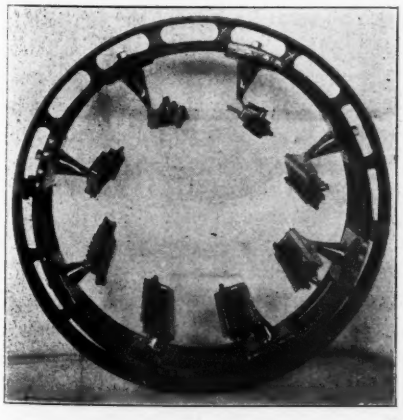
highest grade of rolled copper and are insulated from each other and from the shell with mica. The surface is ample, being designed with reference to the



FIELD COIL AND ARMATURE, SHOWING WIDE ARMATURE CLEARANCE.

amount of heat distributed in commutation and generated by the friction of the brushes.

The brush rigging is so constructed



BRUSH RIGGING.

that independent, individual adjustment of the brackets which carry each set of brush-holders can be made. The cast-iron rocker ring is supported on guides in four brackets bolted directly to the magnet frame, and is mounted so as to be capable of rotative movement for adjusting the position of all the brushes, this adjustment being controlled by the tangential screw and hand-wheel.

All the positive sets of brush-brackets are connected by a copper conducting or bus ring mounted on one side of the rocker ring, and all the negative brush-brackets are connected by a similar ring on the other side of the rocker ring. The exposed portion of the copper bus rings is insulated by a wrapping of cord finished with insulating paint. All machines are fitted with the standard Crocker-Wheeler brush-holders and carbon brushes, the brush area being proportioned with reference to the conditions of commutation.

Telephone Pay Stations.

There is little doubt in the minds of manufacturers and operators of telephones that the use of the telephone would be very much furthered if an absolutely reliable and efficient automatic pay-station apparatus were exploited and placed in advantageous positions for the general use of that class of user who has not enough service to justify him in placing instruments for his particular use.

The latest and most improved station

RATE 5 CENTS
DO NOT put money in until told to do so by operator.
Call exchange in regular manner.
When told by operator insert nickel in slot, then pull lever very down.
Keep receiver off hook.
TEL. No.

PAY STATION FOR ONE COIN.

for the collection of tolls is shown in different forms in the accompanying illustrations, this being, according to the manufacturer, a combination of the best ideas in pay stations which have yet been evolved in the designing of this form of apparatus.

Probably one of the most important features of this new device is the elimination of the difficulty experienced by subscribers in dropping more than one coin in the slots at the same time. When this occurs, the central operator is confused by the double or triple signals, and is, therefore, easily imposed upon by the subscriber. For instance, if the rate should be given him as forty cents, he could, with a faulty style of station, drop in two coins which might not be of the proper denomination, and when the machine was operated, the signal received by the oper-

PAY STATION FOR TWO COINS.

ator would be so mixed up that she could not determine what amount had really been deposited. In this case the subscriber would either insist that the full toll had been paid and receive the proper service, or he would be cut off and the service refused. In any case, the possibility of a dispute would be practically continuous. The maker claims that this new machine does away with all this, for if the subscriber deposits more than one coin at a time, one coin only remains in the station, and the signal must be made for this coin before others can be used. All coins except one are returned through the little pocket at the side, so that the

PAY STATION FOR THREE COINS.

subscriber does not lose his money, but is obliged to give signals, one at a time, and correctly.

Another interesting feature is found in the manner in which the machine re-

turns to a dishonest subscriber all iron or steel slugs which he may attempt to use in place of the proper coin. The interior construction is also arranged so that a combination of a curved slot makes it possible to manipulate wires or strips of metal and thus obtain free service.

These machines are made for different varieties of service, one for five or ten-cent

Wall Pay Station Set for Four Coins.

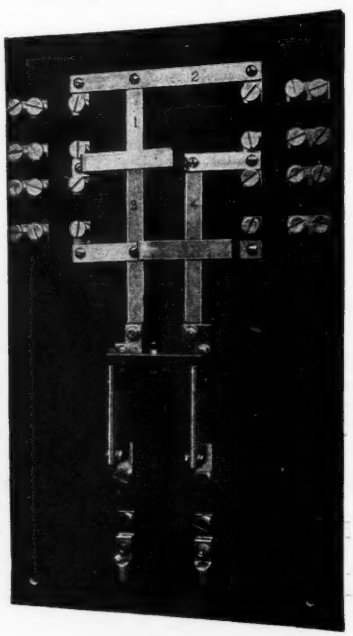
coins only, others for coins of two or several denominations. For long-distance toll work a wall-set is manufactured with slots for five, ten, twenty-five and fifty-cent coins. Operators can not possibly be deceived or confused, as the subscriber

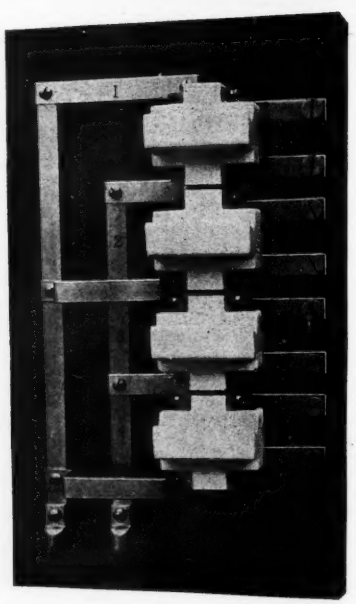
Desk Pay Station Set for Four Coins.

calls the exchange in the regular manner and when told by the operator drops the coins in the proper slots, one coin at a time, and pulls down the lever each time a coin is inserted. The nickel operates the mechanism which strikes one stroke on the bell, the dime accomplishes two strokes on the bell, the quarter makes one stroke on a cathedral gong, and the half dollar operates so that two strokes are made on the gong. These instruments combine many other points of merit that will commend them to a certain class of telephone users, and is believed by the manufacturer, the American Toll Telephone Company, of Cleveland, Ohio, to be the proper solution of equitable charges for automatic pay-station service.

Panel Boards.

One does not have to go back very far to recall the time when almost anything





Improved Panel Boards.

would do for a cutout, and when these so-called safety devices were to be found scattered all over a building, on walls and ceiling, wherever convenience or fancy happened to dictate. This is all changed now, and the modern system of bringing all circuits to panel boards, located at definite distributing points, is demanded by architects and owners generally.

A few typical specimens of this modern device are illustrated in the accompanying engravings, these panel boards being representative of a new line just being put on the market by Zimdars & Hunt, of New York city, and they may be said to embody about all the latest improvements known to be desirable in a device of this nature.

Adjustable Support for Electric Fans.

Messrs. Scott & Williams, of Philadelphia, Pa., have recently introduced what appears to be an exceedingly valuable device in connection with electrical fans. The fan support will receive any of the ordinary makes of fans, and can be adjusted to any angle so that with the ordinary stationary fan all the advantages of an adjustable fan can be secured.

The device is very simple, consisting of a base in which is journaled a spindle having a handle and an angular pivot on its upper end, upon which is pivoted the fan-supporting platform, which is provided with clamping screws and adjustable

Adjustable Supports for Either Desk or Wall Fans.

nuts, whereby the base of the fan is held rigidly to the platform. When so mounted, two movements are possible, one around the vertical pivot by means of the handle shown, and the other movement about the angled pivot, so that by turning these two members so that they occupy different relative positions to each other, the angle of the line of projection may be altered from a low angle to a high angle and, of course, may be maintained in a horizontal plane and be adjusted at any diametrical point.

The device is made in two forms, as shown in the illustrations, one of which is intended for a table or desk and the other for securing to the wall, and angular adjustments are made instantly and without the use of tools.

Recent Refinements in Field Magnet Construction.

At a recent meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers, held in Mansfield, Ohio, Mr. S. E. Huenerfauth, of the Phœnix Electric Manufacturing Company, read the following interesting paper, under the above heading:

The commercial producer of dynamos and motors is continually making compromises between opposing considerations, and the contradictory requirements of the designer and the builder—the technical and the business heads—have resulted in some interesting developments in practical construction. A few of the more recent of these will be discussed in this paper.

It has become well recognized that the limit of sparkless output for a direct-current generator, having a given armature winding, may be varied very considerably by varying the excitation in the air-gap. The greater the magnetic density in the air-gap and the armature teeth, the farther away is the sparkless limit removed—the greater the load that may be carried without commutation troubles. But higher magnetic density means more power for field excitation and lower efficiency because of the hysteresis loss in the armature teeth.

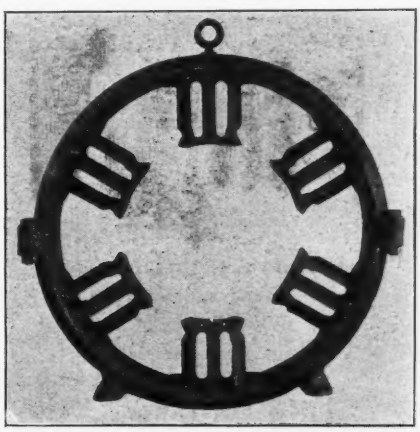
A method adopted by the Phœnix Electric Manufacturing Company for obtaining sparkless commutation without excessive weight of material or expenditure of power consists broadly of the use of slotted magnet poles, without pole-shoes, commutating tips being formed by hollowing out the cores just above the pole-face on each side of the magnet core.

This form of pole combines several advantages. The hollows above the pole-tips reduce the cross-section of the steel so that at no load the outer ribs are highly saturated magnetically at the hollows; consequently the magnetization of the pole-tips varies very little from no load excitation to maximum, and the commutating fringe under the pole-tips remains nearly constant. This construction, combined with the use of slots nearly across the pole-face, prevents distortion of the field flux by armature reaction, and allows the brushes to remain fixed between no load and full load.

The slots in the pole-face further serve to connect the wider slots on the body of the pole with the armature chamber and supply superabundant ventilation to the field coils, carrying away heat from the inside of the coils, whence it is ordinarily least able to escape.

Moreover, the use of polar horns or extensions being rendered unnecessary, the outline of the body of the pole is made the same as a projection on the pole-face outline, so that the field magnet coils may be slipped off without using removable poles—the poles are cast integral with the yoke ring. This feature is a source of joy to the builder, and at the same time is not the slightest detriment to the designer's calculations.

A machine having the usual round magnet cores, with extension pole-shoes, when built so that the reactive kick of an armature coil undergoing commutation exceeds six volts, is almost invariably a hopeless "sparker." The most prominent English designers insist on keeping this reactive voltage down to four or five volts. A 150-kilowatt Phœnix machine with a reactive voltage of eleven and one-half volts per coil is running in an adjacent city without showing the slightest indication of uneasiness at the brushes. It is safe to say that there is not in the world a machine of similar size and of ordinary design that would run a week under full load with such a reactive voltage.



Field Magnet Casting.

The advantage in carrying the reactive voltage up is that it reduces the cost of construction. A reduction of reactive voltage means increased armature diameter, increased number of armature coils and consequently commutator segments. Any one who has tried to build a twenty-four-inch commutator with 600 more segments will appreciate the removal of the necessity for large numbers of coils.

Still another benefit derived from the use of the slotted form of magnet core is that the metal of the pole-face is highly saturated, while the density in the air-gap is quite normal. This supplies an additional barrier to the distortion of the field by armature reaction, without resorting to highly saturated armature teeth, with the accompanying hysteresis loss. A 200-kilowatt machine recently built showed a total armature core and friction loss of two and one-quarter per cent, and a practically distortionless field was obtained with an excitation of less than one per cent.

From an actual test made in the past few weeks of a 150-kilowatt generator, after a five-hours' run, the field coils were cooler by five per cent on the inner surface of the coil than on the outer. We also discovered that by holding a small strip of paper at the opening of the slots at the top of the field coils, the current of air would draw the paper toward the opening. When the armature is in motion, the tendency is to draw the air through the opening at the top, down through the slots on the face of the pole-block, where it has the effect of materially cooling the face of the armature.

These features can not help but appeal favorably to those who are familiar with the design and construction of field magnets, and the advantages can be seen very readily by those who appreciate the advantages of cool and sparkless operation of dynamo electric machinery.

The features outlined herein have been covered by patent applications, as have also two other designs varying somewhat in outline which are more especially adapted to machines of smaller capacity.

High-Tension Cutouts and Automatic Electric Time Switches.

The accompanying illustrations show a line of high-tension arc-light cutouts and automatic cut in and cut out electric time switches, manufactured by Eugene B. Abbott, of Cleveland, Ohio. The particular claim of the manufacturer of this apparatus in reference to the arc-light cutout is that the throw is instantaneous and so arranged in conjunction with the spring as to carry it beyond the dead centre, and owing to the fact that it is so constructed as to lead the current along lines of least resistance away from the point of arc before it breaks connection, the possibility of arcing is minimized.

The box is of cast iron with a close-fitting, hinged cast-iron cover, as is shown in Fig. 1, the contacts and working parts thus being protected from dust and water. The positive and negative contacts can be replaced without removing the box from its position, the contact blade being machined, and ensuring in this direction a parallel blade and a sleeve contact which

may be kept clean and give a large area of contact surface. The contacts and terminals are mounted on one piece of porcelain and are designed so that they can not work loose or become disengaged.

FIG. 1.—CUTOUT WITH CURRENT ON.

These cutouts will take care of from one to fifty lamps of fifty volts each on circuits of from five to fifteen amperes, and it is claimed that the cutout has carried 128 lamps and cut in 6,500 volts without any perceptible tremor in the line. The contacts are of such design that there is always a part of the metal in contact, both on the main line that is to be short-circuited, also on loop or lamp circuit that is to be open-circuited, preventing sparking at the contacts or interruption of lights on the main line. Fig. 1 shows the interior mechanism with the current on, Fig. 2 the appearance with the current off.

Fig. 3 gives a clear idea of the construction and the general appearance of

FIG. 2.—CUTOUT WITH CURRENT OFF.

the automatic electric time switch which is used extensively by lighting companies.

This will switch on a given number of lights or quantity of current at a predetermined time, and later on switch off again, both actions being entirely automatic, no labor or attention being necessary except to wind the clock.

The current operating the magnets is controlled by a shunt from the main circuit which prevents a constant flow of current through the magnet coils, no current being consumed in throwing the switch except when the time arrives for switching on again and when switching off, and then only for a very short period of time. The insulated parts are of porcelain and

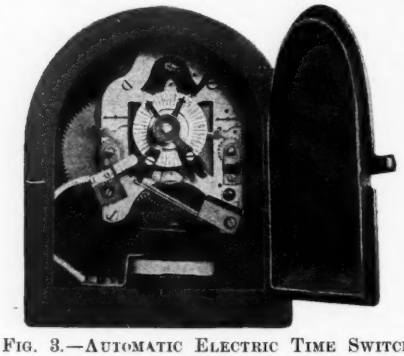


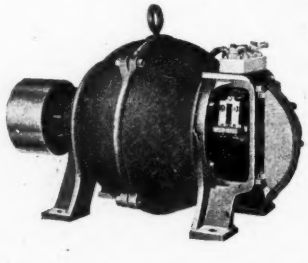
FIG. 3.—AUTOMATIC ELECTRIC TIME SWITCH.

the clock used is a Seth Thomas eight-day jeweled movement.

The switches are built for alternating and direct current, two and three-pole, ten to forty amperes capacity and up to 220 volts, and are designed to carry definite loads on definite voltages.

Single Field Coil Direct-Current Generators.

The single field coil type of generator is the ideal of simplicity and compactness. The most notable feature of this type is the construction of the field magnet, whereby a single energizing coil magnetizes all the pole-pieces and inner pro-

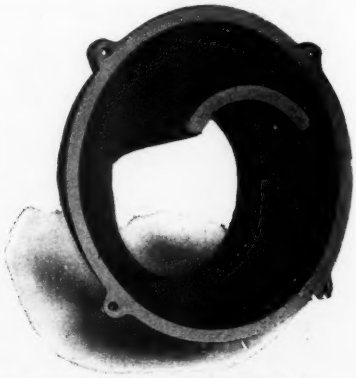


BIPOLAR ROUND TYPE GENERATOR, ONE DOOR OPEN.

tective shell for the winding, completing the magnetic circuit between the poles.

The Sprague Electric Company, of New York, has for many years been manufacturing direct-current dynamos and motors, and its apparatus enjoys a world-wide reputation for all the essentials of electrical and mechanical efficiency.

The accompanying illustrations show in different sections the direct-current generator manufactured by this company, of the single field coil type. Generators of the two-pole single field coil type are known as round type machines; those of



HALF YOKE AND POLE-PIECE, BIPOLAR ROUND TYPE GENERATOR.

the six-pole single field coil type as M. S. type machines. Round type generators are rated from one-quarter kilowatt to eight and three-quarter kilowatts inclusive

HALF YOKE AND POLE-PIECE OF SIX-POLE GENERATOR.

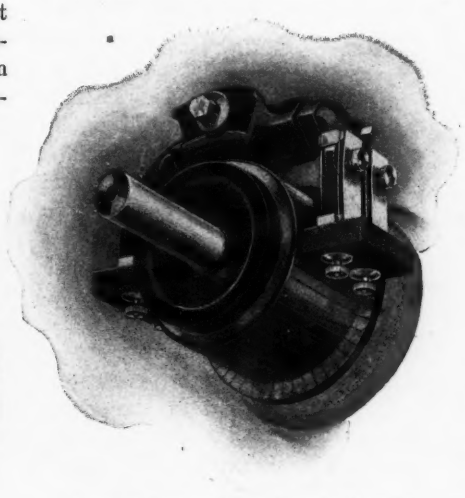
for belt drive, and operated at approximate speeds of from 1,300 to 1,900 revolutions per minute. The M. S. type generators are rated from ten kilowatts to fifty kilowatts inclusive for belt drive, and from four kilowatts to thirty-five kilowatts inclusive for direct-connection. These are rated for speeds from 360 revolutions per minute to 900 revolutions per minute.

The field coil is circular in shape, and occupies a space inside of the frame of the machine, embracing closely all of the pole-pieces, magnetizing them directly, shortening the magnetic circuits, and reducing the magnetic leakage to a minimum. The field coil is wound on a former, and is thoroughly insulated and taped.

The yoke is circular in form, and consists of two steel castings of high per-

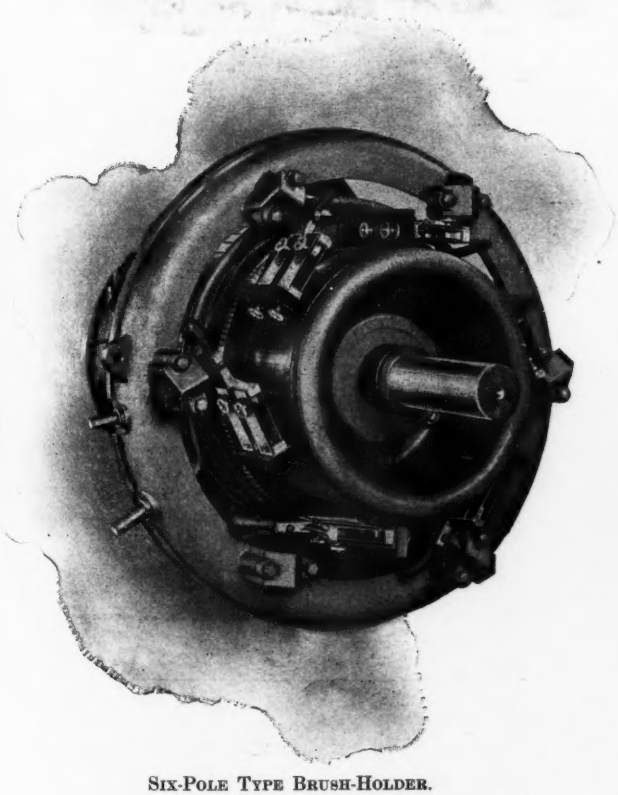
meability, each casting carrying one-half the number of pole-pieces. The pole-pieces, instead of being held in by bolts or screws, are cast in one piece with the yoke. They are alternately reentrant, and together with the yoke form one joint and cylinder that encloses the energizing field coil and protects it from accident or injury. In the magnetic circuit there is but one joint, and that is where the two field yokes are joined together. This form of construction in conjunction with the carefully designed and apportioned pole-pieces and yoke gives a magnetic circuit of small reluctivity and makes a compact and simple frame.

Single Field Coil Yoke.

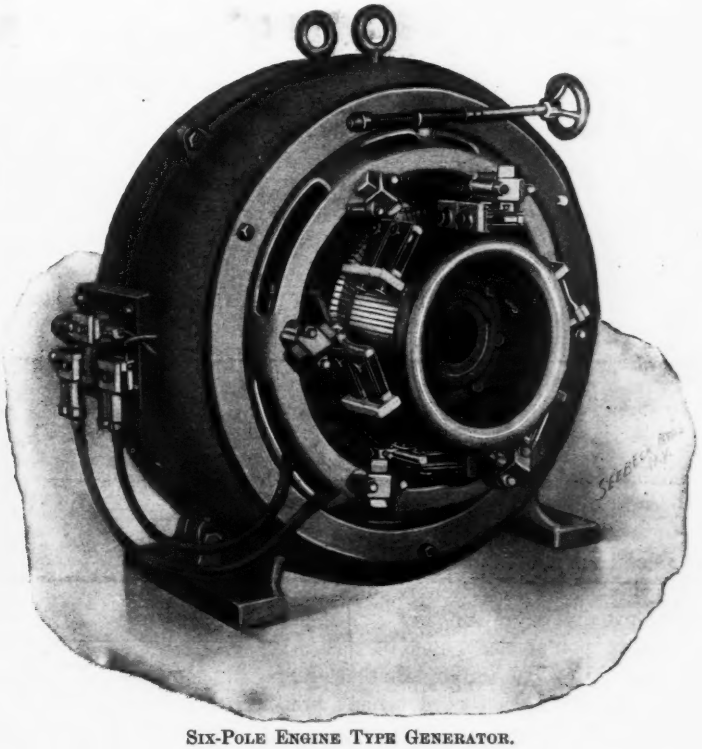


Bipolar Round Type Brush-Holder.

The armature is of the iron-clad type, having slots or grooves in its periphery in which the armature conductors are placed and securely held by rigid retaining wedges which may be easily removed when repair of coils is necessary. The armature consists of laminations of soft annealed sheet steel punchings which are thoroughly japanned, ensuring low core loss and heating. The armature coils are made of pure copper of high conductivity.



Six-Pole Type Brush-Holder.



Six-Pole Engine Type Generator.

The commutator is composed of a proper number of bars of hard-drawn copper, carefully insulated from each other, and of such dimensions as to ensure adequate current capacity to carry the required current without excessive heating, and is of relatively large diameter.

In the round type generators the commutator and brushes are accessible by side doors, which may be left open or closed as occasion may require. The M. S. type is semi-enclosed, the commutator being exposed and readily accessible for inspection and cleaning.

The bearings in all types are of the self-aligning and self-oiling design, and the M. S. type machines are supported by pedestals mounted upon an iron subbase which carries the field yoke.

The brush-holder rocker is so constructed that no part of it or its attachment obstructs from view any portion of the commutator. The bus rings for the M. S. type are mounted on the inside of the brush-holder ring. Carbon brushes of proper dimensions and carefully selected quality are employed for these machines, a carbon-holder of the simplest construction having been invented, which the maker claims possesses the advantages of noiselessness, maximum current carrying capacity, operating in either direction with equal facility, maintaining parallelism of carbons and commutator during entire life of both, utilizing the entire surface of the bars with a consequent even wear over the whole surface of the commutator, and of correcting the known tendency of one or a multiple of carbons to carry more than its due ratio of current.

Electrical Dental Engines.

A very interesting application of electrical motive power for very delicate and light work is that in connection with electrical dental engines. Some of the apparatus manufactured by the Ritter Dental Manufacturing Company, of Rochester, N. Y., is illustrated in the accompanying engravings. Fig. 1 shows a modern dental chair used in connection with a direct-current or alternating-current engine, suspended from proper brackets with relation to the chair, and also the best location for the foot controller which is an important part of the dental outfit. In suspending the motor it is allowed to hang freely from a flexible conducting cord passing over two pulleys on neat brackets, and the motor is counterbalanced by a suitable weight which permits it being raised or lowered by the slightest pressure. In connection with the yoke, in which the motor is free to turn on a horizontal axis, it permits an easy and almost universal movement avoiding the constant pull on the hands which is common with rigidly supported engines. The electrical dental engine occupies no floor space, and the surgeon when through simply drops the instrument and swings the apparatus out of the way.

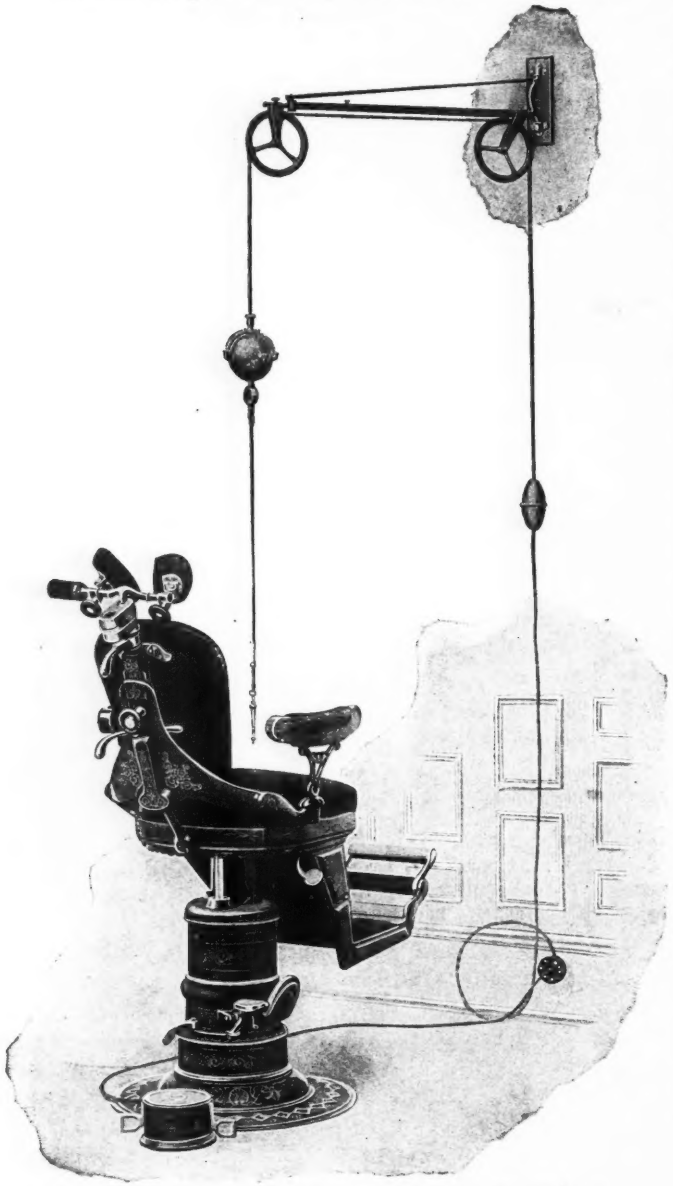


FIG. 1.—MODERN DENTAL CHAIR, ENGINE AND CONTROLLER.

The cable sleeve and hand-piece are thoroughly insulated from the framework of the motor, and this together with the care taken in insulating the wire winding, entirely avoids the possibility of getting a shock. The entire motor is enclosed in an antique silver-plated sphere, four and one-half inches in diameter, making it pleasing in appearance and at the same time protecting it from dust and dirt. By removing two small thumb screws, one on each side, the sphere parts in the middle, giving free access to all portions. The efficiency is high. The armature or revolving portion is carefully made, and it is claimed that there is absolutely no sparking at the commutator. The speed of these motors may be varied at will from 1,000 revolutions per minute to 4,000, a range found in practice to be all that is ever needed.

A portable controller is supplied on both direct and alternating-current engines. There is a single lever projecting through opposite portions of the case with which the motor is started, stopped and reversed and the speed regulated. The controller can be placed in any position, but it is probably most desirable just behind the chair. When in this position, by means of a double lever, the operator has control of his engine from either side of the chair without moving the controller. When the lever occupies a central position no current is flowing and the motor is at rest. A slight movement to the right runs the motor in one direction and a movement to the left reverses, the speed being regulated by the distance the lever is moved from the centre. (Fig. 2.)

FIG. 2.—PORTABLE CONTROLLER.

Fig. 3 shows the Columbia electric laboratory lathe. The chucks for carrying the carborundum wheels are placed directly on the end of the shaft. These chucks have a slightly tapering hole and this shaft bears a tapering end to correspond. The knurled nuts shown on the ends of the bearings are for the purpose of forcing the chucks off the shaft by giving them a few turns forward. The small knob on the front of the lathe controls the speed.

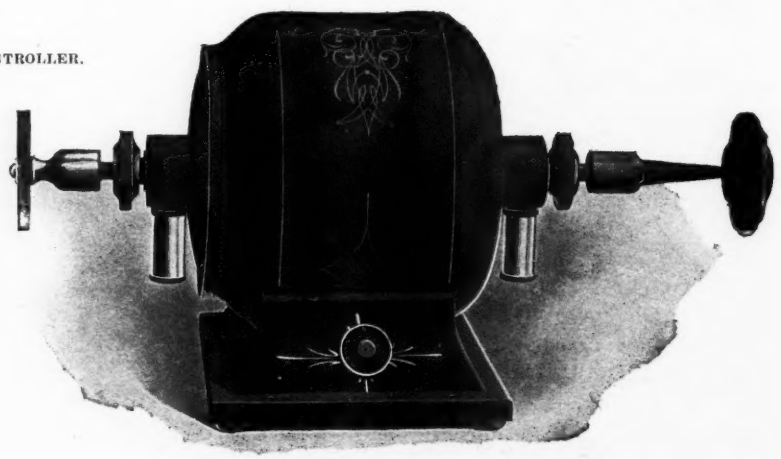


FIG. 3.—SMALL LABORATORY LATHE.

CURRENT ELECTRICAL NEWS

COMMERCIAL NEWS

DOMESTIC AND EXPORT

ELECTRICAL GOODS IN ENGLAND—The returns of imports of foreign electrical goods and apparatus into England just issued for March show a total of only £47,158, as compared with £54,516 in the preceding month, and £130,076 in March, 1901. As far as the year has gone, there has been a marked decline in these imports, the aggregate for the three months ending with March having attained only a value of £164,978, as against £321,689 in the first three months of last year.

AN EXPENSIVE ORDINANCE HANDED IN—The aldermen's committee on streets and highways have reported favorably on an ordinance providing that on and after July 1 all telephone, telegraph and other electric wires in the greater city of New York shall be put underground. The effect would be to compel the Brooklyn Rapid Transit Company and the Huckleberry Road to bury their feed wires underground. The ordinance, however, has been held over for further consideration.

CUBA'S TELEGRAPH LINES—The 5,000 miles of telegraph lines established by the United States Signal Corps in Cuba have been transferred to representatives of the new republic. The system has brought into the Cuban treasury within the past year some $100,000, and in addition has transmitted free official business for the entire island, which at the same rate would have cost more than $200,000. The material of the line has been very largely paid for out of the Cuban revenues, and a Cuban force has been gradually installed, so that the transfer was effected without any friction or deterioration of the service.

LARGE STREET RAILWAY SYSTEM TO CHANGE HANDS—The lease of all the trolley lines in Philadelphia operated heretofore by the Union Traction Company has passed to the new corporation controlled by the Mack Syndicate. The transfer brings under the management of the new concern a railway system comprising a trackage of over 480 miles. The lease goes into effect July 1, and by that time it is announced everything will be in readiness for the Rapid Transit Company to take over the property and operate it. The order of the board of directors of the Rapid Transit Company is about as follows: John P. Parsons, P. A. B. Widener, William L. Elkins, George D. Widener, John M. Mack, Michael Murphy, W. H. Shelmerdin and J. J. Sullivan.

STREET RAILWAY DEAL—A merger embracing control of the street railway, lighting, heating, ice factory and kindred interests at Norfolk, Va., and neighborhood has been settled, an underwriting syndicate being formed by Messrs. Alexander Brown & Sons, J. W. Middeldorf & Company, of Baltimore, and John L. Williams & Sons, of Richmond, Va., to finance the deal. There are twelve companies to be consolidated: Newport News & Old Point Railway and Electric Company, Citizens' Railway, Light and Power Company, of Newport News; Norfolk & Atlantic Terminal Company, Danville Railway and Electric Company, Newport News Gas Company, Distilled Ice Company, Newport News; Norfolk Railway and Light Company, City Gas Company, Norfolk; National Gas Company, Berkley; Berkley Street Railway Company; Portsmouth Electric and Gas Company, Norfolk; Portsmouth & Newport News Railway Company. These companies embrace nine electric railway systems owning and operating 120 miles of trackage. There are also six ferry lines, five electric lighting plants, two ice plants and two gas companies in addition. The new name of the company will be the Norfolk, Portsmouth & Newport News Company. Its total capitalization will be $9,000,000.

PROPOSED ABSORPTION OF SPRAGUE ELECTRIC COMPANY BY THE GENERAL ELECTRIC COMPANY—It was stated in the newspapers last week that circulars had been sent out to the bond and stockholders of the Sprague Electric Company, signed by Mr. John Markle, its president, to the effect that an offer had been made by the General Electric Company to acquire control of the Sprague Electric Company. It is alleged that the circulars state that the terms of the offer have already been approved by many of the largest bond and stockholders, and that the president favors their acceptance. The terms of the plan by which the merger is to be effected are briefly as follows: The Sprague Electric Company has three classes of securities, five per cent bonds, common stock, and preferred stock. The plan proposes to give to the bondholders of the Sprague company fifty-five per cent of par value for each bond in Otis Elevator preferred stock, and forty-five per cent in cash. To the Sprague preferred stockholders it is proposed to give a General Electric three and one-half per cent debenture bond for each share deposited. To the common stockholders it is proposed to issue for each share 41.9 per cent of share of the par value of $100 of common stock of the Otis Elevator Company, and 20.42 per cent of the General Electric Company's forty-year-old gold debenture bonds of the par value of $100. The Otis Elevator stock that appears in the transaction is due to the fact that some years ago the Sprague Electric Company sold out its elevator business to the Otis company, receiving stock in exchange which has since been in the treasury. The proposed plan involves a distribution of the company's treasury assets before the total absorption is completed. It is stated that the agreement will not become operative until the consent of at least seventy-five per cent of the holdings of each of the three classes of Sprague Electric Company's securities has been obtained. The capital stock of the Sprague company is stated to be $5,000,000. In an interview with Mr. A. H. Davis, of the Sprague Electric Company, he stated that he would not deny that negotiations of the sort described above are now pending, but that these negotiations were not yet complete. It was probable, he thought, that the arrangement as outlined would be caried out, but this was not yet certain.

ELECTRIC LIGHTING

TALLADEGA, ALA.—Negotiations are now pending with an eastern corporation to locate a $600,000 light, power and traction company and a cotton mill in this city.

EDWARDSVILLE, ILL.—A franchise has been granted for a term of fifteen years to J. R. Bennett, of Wyandotte, Mich., to furnish electric lights and electric power for public and private purposes.

HOPEWELL, N. J.—It is rumored that the Hopewell Electric Light, Heat and Power Company will extend its lines as far as Glen Moore. The work on the new powerhouse being erected by it at Rocky Hill is progressing rapidly.

BAKER CITY, ORE.—After a careful estimate into the receipts of the city it was decided that it would be possible to establish an electric lighting system, and a committee has been authorized to make out plans looking to this accomplishment.

NASHVILLE, TENN.—The Cumberland Electric Light and Power Company is to have a new power station in Nashville. The company has purchased blocks fronting 447 feet on North Front street, running back to the Cumberland River and adjoining the city electric plant, for the site of a complete, up-to-date electric light and power plant.

WARREN, OHIO—Mayor W. C. Ward, in his annual message to the city council, urges municipal ownership of the Warren water and electric light plants. Within the next three years the city may, if deemed advisable, avail itself of a five-year option on the water plant. This question may be submitted to a vote of the people. An investigation toward the erection of a city light plant is already in progress.

SAN FRANCISCO, CAL.—The McCloud Electric Power Company has just let a contract to an eastern firm for the erection of a 10,000-horse-power plant in Shasta County. This company is incorporated with a capital of $1,500,000, and has already issued $500,000 in thirty-year five per cent gold bonds, which have been taken by the contractors for the erection of the proposed plant. The company claims to have secured considerable patronage for both light and power as soon as ready to furnish the same.

KNOXVILLE, TENN.—It is announced by local authority of the Knoxville Power Company that work on a large dam on Little River in Blount County will begin before the end of the present month. It is proposed to operate sawmills, tanneries, and similar manufacturing plants with electrical power from the main plant. Contracts have already been made with a number of the largest manufacturing plants of the city for the use of power and lighting on the completion of the dam and power plant. The dam will be some twenty-five miles from this city, and the initial investment will be in the neighborhood of $3,000,000.

ELECTRIC RAILWAYS

TROY, N. Y.—The Hudson Valley Railroad has built two electrical engines. They are to be used first as an experiment in hauling freight cars.

CHICAGO, ILL.—It has been announced that the Chicago City Railway Company has made plans for $8,000,000 worth of improvements. The improvement plans embrace new car sheds and a remodeled power supply system.

GLENS FALLS, N. Y.—The street railway company is contemplating extensive improvements during the coming summer. There will in all probability be about $300,000 spent by the company in fixing its lines and making other improvements.

STOCKTON, CAL.—The Stockton Electric Street Railway system has been sold out and the new interests will extend the main line and build branches to all parts of the city. A system may also be run into the country and a road to Lodi is assured.

SYRACUSE, N. Y.—The Syracuse Railroad Construction Company is acquiring land along the bank of the Owasco River. It proposes to put up a big electric plant for furnishing power to the Auburn city railway and to interurban lines from Skaneateles to Syracuse, and also for furnishing electricity for mercantile use.

SAN FRANCISCO, CAL.—The Northern California Power Company has asked for a franchise to run electric power lines into and through Glenn County. It has been agreed that the company would have lines running into Glenn County within thirty days after the franchise had been granted and would reach Willows within four months.

PHILADELPHIA, PA.—The shareholders of the Union Traction Company have ratified a lease to the Philadelphia Rapid Transit Company for 999 years. The lease is to run from July 1, 1902. The annual rental for the first two years is to be $900,000, for the second two years $1,200,000, for the third two years $1,500,000, and $1,800,000 each year thereafter.

INDIANAPOLIS, IND. — The Indianapolis Street Railway Company has plans made for extensive improvements. It has been estimated that nearly half a million dollars will be expended during the summer and fall in new equipment, new buildings, and extension and rebuilding of lines. New power machinery is to be installed and new car barns will be erected.

DUBOIS, PA.—The Dubois trolley line, owned and operated by a local company, has been sold to New York capitalists. The amount of purchase money was not made public. The sale includes the entire equipment together with the electric light plant and contracts for lighting the city for eight years. The line will be extended to Falls Creek and other neighboring towns.

CLEVELAND, OHIO—Mayor Johnson and the majority in the city council have been held in a decision by Judge Strimple in the Common Pleas Court affirming the legality of the franchise recently granted for a three-cent fare street railway system. Immediately afterward Judge Caldwell in the Circuit Court at Elyria granted a temporary injunction enjoining the beginning of work on the new system.

SCHENECTADY, N. Y.—At a special meeting of the directors of the Fonda, Johnstown & Gloversville Railroad and the Amsterdam Street Railroad it was voted to double-track the Cayadutta Electric Railroad from Gloversville to Tribes Hill, and the Amsterdam Railroad from Amsterdam to Schenectady. The line is being built for a double-track route, but it had not been decided to lay two tracks for the present.

CLEVELAND, OHIO—Judge Wing, of the United States Circuit Court, has issued an order allowing Receiver Albion E. Lang, of the Lake Shore Electric Railway Company, to issue $292,730 worth of receiver's certificates for the purpose of completing the construction of the road and making improvements. The Lake Shore Electric Railway Company, one of the Everett-Moore properties, operates over four divisions between Cleveland and Toledo.

WHEELING, W. VA.—The Wheeling & Steubenville Traction Company will begin the construction of its electric line from Martin's Ferry to Steubenville in a very short time. This is the name it will operate under between the two points, but like the Wheeling & Western company from Bridgeport to St. Clairsville, it is really the property of the Wheeling Traction Company. It intends to commence work at the earliest possible moment and complete this fall if possible.

JACKSONVILLE, FLA. — Negotiations are pending in this city for the sale of the Jacksonville street car line to Mr. George J. Baldwin, of Savannah, who is in the city representing northern capitalists, and is now looking over the property with a possible purchase in view. The Jacksonville Street Railway is valuable property and it has been a paying investment for years. It is splendidly equipped, and penetrates every suburb of Jacksonville, and extends to the city cemetery and to Phœnix Park and has no opposition.

OGDENSBURG, N. Y.—Chester Snyder, as trustee for a syndicate of ten Pennsylvania capitalists, has purchased all the bonds of the Ogdensburg street railway not held by the syndicate at par value, and also paid all outstanding indebtedness, taking full control and ownership. G. C. Davis, of Easton, Pa., was placed in charge as manager. All the stock of the Ogdenburg Gas Company is arranged for by the Pennsylvanians, who already hold the entire stock of the Ogdensburg Power and Light Company. The bonds and indebtedness of these companies represent nearly $300,000.

NEW ORLEANS, LA.—It has been announced that the street railway and electric lighting company of New Orleans are to be consolidated with a capitalization of $80,000,000. A corporation known as the New Orleans Railways Company has been organized with the above capitalization, divided into $40,000,000 four and one-half per cent sinking fund mortgage bonds, $10,000,000 four per cent cumulative preferred stock, and $30,000,000 common stock.

NEW INCORPORATIONS

HARRISBURG, PA.—Beaver Valley Water Power Company, Eastville. $1,000.

PIERRE, S. DAK.—The Buck Electric Company. $1,000,000. Incorporators: S. P. Second, I. W. Gardner, R. M. J. Tallman.

SPRINGFIELD, ILL.—Carbondale Telephone Company; Carbondale. $5,000. Incorporators: J. B. Bundy, D. B. Parkinson, D. M. Parkinson.

DENVER, COL.—Larimer Light and Power Company, Fort Collins. $100,000. Incorporators: Irving W. Bonbright, Leonard E. Curtis and Franklin E. Brooks.

MADISON, WIS.—Farmers' Telephone Company, Leeds; $5,000; incorporators: George Kronche, Jay Brady and H. J. Kronche. Kenosha Electric Railway Company; $10,000; incorporators: Gerald R. McDowell, H. M. Baldwin and Jacob Kronche.

HELENA, MONT.—The Montana Power and Transmission Company, incorporated under the laws of New Jersey, where it is carrying on business on the Big Hole River, filed its statement with the Secretary of State, showing its capital to be $1,000,000 and its liabilities $813,000.

DOVER, DEL.—Tonopah Water and Power Company, of Carson City, Nev., to furnish water and electricity for use of lighting, heating or any other purposes. $1,500,000. Incorporators: Lewis H. Rogers, J. A. Yerrington, Carson City, Nev.; J. H. Daskell, Sandy Hill, N. Y.; J. W. Gardner, Brooklyn, N. Y.

JERSEY CITY, N. J.—Ritzer Transformer Manufacturing Company, 15 Exchange Place, Jersey City, N. J.; $100,000; incorporators: Conrad J. Ritzer, William E. Vandemorg, Thornton Parker. Woodbourne Electric Light, Heat and Power Company, Sussex, N. J.; $30,000; incorporators: Harvey D. Van Grasbeck, Charles H. Crisman, John L. Swayge.

LOUISVILLE, KY.—The Louisville & Mt. Washington Electric Railway. $10,000, to be increased to $400,000. Incorporators: A. S. Rice, Cynthiana, Ky.; Younger Alexander, Lexington, president of the Lexington & Georgetown railway; William Adams, Lexington; E. B. Berry, Cynthiana; N. S. Keith, Cincinnati; C. C. Tennis, Pittsburg; Peyton N. Clarke, Louisville; Clint C. McClarty, Louisville, and John J. McHenry and L. H. McHenry, Louisville.

COLUMBUS, OHIO—The Mahoning Valley Railway Company, Youngstown, increased its capital stock from $1,500,000 to $2,500,000. Warrensville Telephone Company, Warrensville; $5,000. Bellefontaine & Sidney Electric Railway Company, Bellefontaine; $10,000. Citizens' Telephone Company, Beaver, increased its capital from $20,000 to $40,000. Collingwood Horney Telephone Company, Collingwood, increased its capital from $30,000 to $40,000.

ELECTRICAL SECURITIES

Prices in almost all lines during the week just closed have advanced steadily, the general trend of conditions being steadily upward. As compared to a week ago many material gains in prices are indicated. The outside public still stays obstinately out of the market, and many commission firms are feeling severely the continued reduction in business. The steady and almost uninterrupted daily improvement in security values is all the more significant and satisfactory, as it has been made in the face of the bad conditions due to the coal strike, the entire market seeming to have broken away from this labor controversy as a factor. The main causes for improvement are to be found in the favorable developments made in the monetary situation, the better crop outlook, and the hopeful anticipations for an early settlement of the South African war. This latter condition has stimulated British, as well as Continental markets, and foreign buying of American stocks has been an important local financial factor.

ELECTRICAL SECURITIES FOR WEEK ENDING MAY 24.

New York:	Closing.
Brooklyn R. T.	68¼
Con. Gas	223
Gen. Elec	315
Kings Co. Elec	196
Man. El	133
Met. St. Ry	150
N. Y. & N. J. Tel. Co	176
Westinghouse Mfg. Co	215

New York & New Jersey Telephone sold during the week in odd lots at prices ranging from 176 to 178, five Telephone bonds selling at 114 with interest. There is less and less of this stock upon the market as time goes on, and it is apparent that those who are the holders of it are not inclined to part with it, owing to their calculations that they have in hand a pretty good thing.

There was considerable activity in Brooklyn Rapid Transit during the latter part of the week, with considerable buying. In connection with the Brooklyn Rapid Transit, the provisions of the tunnel contract published last week are interesting in view of the fact that the Brooklyn Rapid Transit Company is expected to become a bidder. The total gross earnings of the Brooklyn Heights and Kings County and Suburban for this year are $2,807,015, or an increase over last year of $156,781. Operating expenses for the 1902 quarter were $1,979,661, as against $1,776,213 in 1891.

Boston:	Closing.
Am. Telep. & Tel	179
Edison Elec	276
Mass. Elec. pf	96½
New England Tel	147
Western Telephone & Telegraph	101

The earnings of the Boston Elevated are said to be exceedingly heavy, the few last Sundays in this month having been record days in the earning capacity. The proposed issue of $5,000,000 of new preferred stock by the Massachusetts Electric Company is looked upon very favorably by those who already hold stock. There has been good buying of the common by both Boston and New York interests. It is understood that in the further expansion of the road it is not intended to increase the common stock.

Philadelphia:	Closing.
Elec. Co. of America	7
Elec. Stor. Bat. c	82
Elec. Stor. Bat. pf	83
Philadelphia Elec	5½
Union Traction	40¾
United G. I. Co	103½

The Philadelphia Electric Company has declared a dividend of 15 cents, payable June 16 to stockholders of record May 31. John M. Mack has been elected a director of the Union Traction Company, of Philadelphia, succeeding Thomas Dolan, resigned.

Chicago:	Closing.
Chicago Edison Light	175
Chicago Telep	170
Metropolitan El. pf	90
National Carbon	25
National Carbon pf	95
Union Traction	18⅞
Union Traction pf	51

TELEPHONE AND TELEGRAPH

SYRACUSE, N. Y.—The American Telephone and Telegraph Company will begin in a short time the construction of a new long-distance telephone line connecting Syracuse and other cities with Canadian cities.

SAN FRANCISCO, CAL.—The Pacific States Telephone and Telegraph Company has a large repair shop at San Francisco, Cal., where there are employed about 150 men and boys on work which comes in from all over the coast.

NEW YORK, N. Y.—It has been announced that the Pennsylvania Railroad will not continue its contract with the Western Union Telegraph Company for use of its wires after June 1, 1902. It is believed that closer relations will be established with the Postal Telegraph Company.

FALL RIVER, MASS.—The Fall River Automatic Telephone Company increased the number of its subscribers during the first six months of operation about sixty-two per cent and has now about 800 telephones in service. The underground system, pole lines, exchange building and central station equipment have capacity for 3,000 subscribers.

PHILADELPHIA, PA.—An opinion has been handed down by Judge Dallas in the United States Circuit Court, refusing an injunction in the equity proceeding brought by the Western Electric Company, of Chicago, against the Keystone Telephone Company, of Philadelphia. The Western company sought to have the defendant restrained from making an alleged infringement upon its patent for telephone switchboards.

WICHITA, KAN.—A new long-distance telephone line connecting Wichita with points in Oklahoma and Kansas is now being constructed in Oklahoma from El Reno. The line has been constructed to Mangum, Granite, Hubbard and Chickasa and will be run on to Wichita and thence to Topeka and Kansas City. The company is known as the Topeka & El Reno Telephone Company, and will establish local exchanges in each of the cities through which it passes.

MENOMINEE, MICH.—It is announced that an independent telephone line will be put through this summer between Duluth, connecting the cities of the Fox River Valley in Wisconsin. It is proposed to install a service owned and controlled by a company operated with Green Bay capital. A new toll system is being organized coming from Duluth through the upper peninsula of Michigan and Wisconsin, and finally connecting with another system at Chicago.

TOPEKA, KAN.—It is understood that plans are being worked up whereby several of the independent telephone companies in Kansas are to be consolidated into one new company. Mr. C. S. Jobes is the leading spirit of the organization, and it is said that a number of prominent Kansas men, including Frank Brown, J. C. O. Myers, Cyrus Leland and Morton Albor, are associated with him in this issue. It is expected that it will take about $750,000 to complete the deal and equip the lines with the latest and most improved appliances.

ROCHESTER, N. Y.—A decision has been filed by the referee, Theodore E. Hancock, by which the Bell Telephone Company has gained a case whose importance is considered of very great extent. The city of Rochester is the plaintiff in the proceedings, which were begun in 1899, to restrain the Bell Telephone Company from completing a conduit which it had begun to construct in Oxford street, and to compel the company to place its cables in the conduit of the Rochester Gas and Electric Company in that street. The referee decides the case upon the ground that it is dangerous to place telephone wire in the same conduit with electric lighting and power wires.

LEGAL NOTES

INJURY FROM ELECTRIC LIGHT APPLIANCE—Continued use by a storekeeper of an appliance for hanging up and carrying about a movable electric light which is defective because of insufficient insulation is held in Griffin *vs.* Jackson Light and Power Company (Mich.), 55 L. R. A. 318, to be an intervening agency between the negligence of the company in failing to keep the appliance properly insulated, and an injury to a stranger attempting to use the light while delivering goods in the store so that he can not hold the company liable for the injury.

THE RIGHTS OF A TELEPHONE COMPANY—A telephone company, although having a monopoly of the business in a particular city, is held in Gardner *vs.* Providence Telephone Company (R. I.), 55 L. R. A. 113, to have a right to deprive a customer of service upon his refusal to discontinue the use in connection with its wires on his premises of extension instruments not furnished by it where it is able and willing to furnish such instruments upon reasonable terms. A telephone company is held in state ex rel Gwynn *vs.* Citizens' Telephone Company (S. C.), 55 L. R. A. 139, to have no right to impose as a condition of extending its facilities to one desirous of obtaining them an agreement not to use a rival system.

INDUSTRIAL ITEMS

A. L. IDE & SONS, Springfield, Ill., have made an unusually large number of sales of "Ideal" engines during the last month.

THE ELECTRIC APPLIANCE COMPANY, Chicago, Ill., reports that its orders for Packard incandescent lamps have broken the record for recent months.

THE DIRECT UNITED STATES CABLE COMPANY, on account of the demolishment of the building at 40 Broadway, has just moved its main office into new quarters at 60 New street, New York city.

THE ELECTRIC STORAGE BATTERY COMPANY, of Philadelphia, Pa., has issued an interesting and instructive treatise on the storage battery in the commercial operation of electric automobiles, by W. H. Palmer, Jr.

THE EASTERN AUTOMATIC TELEPHONE COMPANY announces that it has removed its offices to 161 Summer street, rooms 53 and 54, near South Station, Boston. The new telephone number will be 1474-4 Oxford.

THE SPRAGUE ELECTRIC COMPANY, New York city, has equipped the plant of the United States Playing Card Company, Cincinnati, Ohio, with a complete outfit of motors for electrotyping and engraving machines.

THE KELLOGG SWITCHBOARD AND SUPPLY COMPANY has contracts for equipping exchanges in Milton, Iowa; Gaylord, Mich.; Flushing, Ohio; Dallas, Pa.; Herndon, Va.; Wadena, Minn.; Johnstown, Pa., and Safford, Ariz.

THE MONTAUK FIRE DETECTING WIRE COMPANY is very successfully installing its fire detecting wire in apartment-houses and business installations. Several testimonials recently received by the company endorse very highly the utility of the apparatus.

THE ELECTRIC APPLIANCE COMPANY, Chicago, Ill., reports that its sales of incandescent lamps have become so large that it has been found necessary to make special arrangements, both in the office and shipping forces, to handle this branch of the business.

THE LORAIN STEEL COMPANY, Lorain, Ohio, and Johnstown, Pa., is advising its patrons that its New York city offices have been moved from the Battery Park Building to new offices in the Century Building, 74 Broadway, New York city, on the nineteenth floor.

THE CONVERSE TRANSFORMER COMPANY, Pittsburg, Pa., manufactures transformers for lighting, power for special uses. This company makes a specialty of transformers for high-voltage achievements, at the same time not overlooking the requirements in smaller or lower voltage transformers.

THE EMERSON ELECTRIC MANUFACTURING COMPANY, St. Louis, Mo., is meeting with great success in sales of its 1902 fan motors and ceiling fans for alternating current. A beautiful catalogue in colors, with numerous half-tone illustrations and ample descriptive matter, will be mailed on request.

THE PAYNE ENGINEERING COMPANY, New York city, is sending out a neat pamphlet in which has been reprinted an article from the January and February numbers of the *Engineering Magazine* on the "Economy of Isolated Electric Plants," by Isaac D. Parsons. This will no doubt be of great interest to many in the electrical field.

THE STIRLING COMPANY, manufacturer of water-tube safety boilers, with general offices in Chicago, Ill., has moved its New York office from the Havemeyer Building, at 26 Cortlandt street, to new quarters in the Engineering Building, 114 to 118 Liberty street, New York, room 907. The telephone number will still be 1480 Cortlandt.

THE CRUSE CONTROLLABLE SUPERHEATER COMPANY, Salfield, Manchester, England, has favored some of its friends in this country with a handsome pamphlet on "Superheating and Superheaters." This is interesting and instructive in a very high degree, and is replete with carefully executed diagrams and tables pertaining to this phase of engineering.

THE AMERICAN BLOWER COMPANY, Detroit, Mich., has issued two splendid bulletins, No. 139 illustrating its dry-kiln apparatus, and No. 140 illustrating its disc ventilating fans. Both of these catalogues are splendidly printed, and added interest is given to the work by numerous half-tone engravings, the letterpress being very comprehensive and carefully arranged.

MESSRS. MCKENNY & WATERBURY, 181 Franklin street, Boston, Mass., note among several large contracts received during the week, for electric and gas lighting fixtures, the Light Guard Armory, Bedford Home for Aged Women in Boston, Samoset Hotel, Bay Point, Me., and several summer cottages in New England and over 100 apartments in Boston and suburbs.

THE UNION SWITCH AND SIGNAL COMPANY, Swissvale, Pa., has been awarded by the Delaware, Lackawanna & Western Railroad an order for 125 Union electric two-arm semaphore signals, relays and other material for the equipment of forty miles of double track with automatic block signals. This is the third large order placed with this company for this type of signal of which there are now 286 in use on the Delaware, Lackawanna & Western.

THE WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, Pittsburg, Pa., has recently issued an interesting and attractive circular describing electrical motor vehicle equipments. This company has for five years supplied motors to the electrical industry, and is now offering a complete line of standard automobile equipments, comprising everything of an electrical nature, except storage batteries, pertaining to the motive power of an electric vehicle of any type or size. The circular will be sent upon request.

THE COMMERCIAL ELECTRICAL SUPPLY COMPANY, St. Louis, Mo., has secured the contract for supplying the electrical fittings on the exposition grounds, amounting to $36,895. The material to be supplied represents electrical fittings of every description, including cutouts, plugs for fuses, glass and porcelain knobs, wire, porcelain tubes, cleat receptacles, glass insulators, ceiling rosettes, fusible attachment plugs and other fixtures. Mr. Wm. F. Nolker is president, Mr. L. T. Nolker, vice-president and treasurer, and Mr. W. H. Nolker, secretary, of this company.

THE SPRAGUE ELECTRIC COMPANY, New York city, has found it necessary, owing to the increasing business of its Boston office, to move from 176 Federal street to the Weld Building, where it will be pleased to receive communications to this point in future. A large number of men, representing the various departments of this company, spent a very pleasant day on Saturday, May 17, at New Dorp, S. I. The office and sales department, under whose management this outing was given, had a thoroughly enjoyable time, and the affair has been voted on all sides a great success.

THE AMERICAN INTERIOR CONDUIT COMPANY, Waukegan, Wis., is the sole manufacturer of "Richmondt" electro-galvanized conduit fittings. With this conduit the deposit of zinc is heavy enough to form an absolute protection against rust and adheres so perfectly to the metal that it will not peel, scrape or chip off no matter how roughly the conduit may be handled. The couplings may be started by hand without first running over the thread with a die, as there is no enamel to be removed. The composition of the exterior surface is such that any covering of paint may be readily applied, the zinc taking the paint with great facility. Mr. William S. Brown is the New York sales agent, with headquarters at 39-41 Cortlandt street.

THE THOMAS S. CLARKSON Memorial School of Technology at Potsdam, N. Y., will hold its graduating exercise in June, 1902. The list of graduating theses is a splendid one, and embraces the following interesting subjects: "Development of the Water Power of High Falls on Deer River." "A Study of the Possibilities of the Development of Water Power on the Indian River." "A Design for a Power Plant on the Indian River." "Investigation of the Properties of Liquid Condensers." "Influence of Chemical Composition on the Electric Conductivity of Wrought Iron and Soft Steels." "Performance of a Motor-Generator Set *vs.* a Rotary Converter of the Same Capacity." "The Design, Construction and Performance of an Experimental Polyphase Transmission Line." "An Experimental Study of a Single-Phase Induction Motor." "Installation of and Experiments on a Fifteen-Horse-Power Otto Gas Engine." "Experiments on the Flow of Steam through Rectangular Orifices." "Design of a Compound Marine Engine."

OBITUARY NOTICE

MR. W. J. MURPHY, chief electrician of the cableship Grappler and a very well-known British cable telegraph engineer, with eight other British telegraph engineers and officers, was killed by the destruction of that vessel in the harbor of St. Pierre, Martinique, during the recent volcanic explosions.